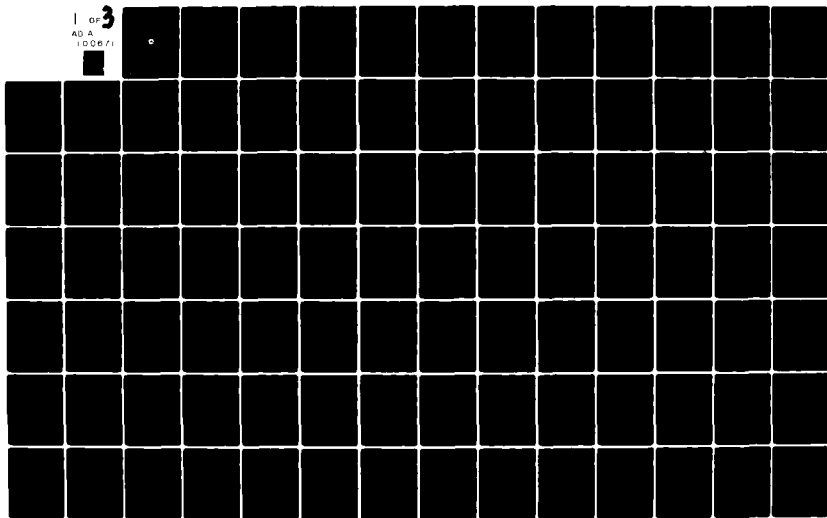


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OFFSHORE INSTALLATIONS AND THEIR RELEVANCE TO THE
COAST GUARD THROUGH THE NEXT TWENTY-FIVE YEARS.

VOLUME II
DETAILED FORECASTS

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16. Abstract This three-volume study forecasts the universe of offshore installations (OSI) in waters proximate to U.S. territory out to the year 2005, and assesses the impact of the growth in numbers and types of these installations on the Coast Guard. Volume I describes the global, regional, national, and subnational forces operating to promote or inhibit the growth of the OSI universe; presents a forecast of the OSI universe resulting from the impact of these forces; describes the likely impact of this growth on the Coast Guard; suggests a set of alternative strategies that appear feasible and promising for the Coast Guard; and offers recommendations for the Coast Guard. Volume II presents detailed forecasts of a variety of categories of offshore installations related to energy, food, minerals, industrial expansion seaward, military and space, transportation, and science and technology. Volume III contains appendices for each of the key chapters of Volume II; the data and rationale supporting the forecasts of Volume II are presented. The conclusions of the study are summarized: o By the year 2005 the population of oil and gas OSI will have expanded very significantly; OTEC installations will be a distant second; all other types of OSI will be a still farther distant third. o The expansion of the OSI universe will increase the operating load on the Coast Guard enormously by the year 2005; there will be a strong need for decision to either expand Coast Guard capability or to reduce Coast Guard load. o The study recommends that the Coast Guard opt to move in a direction that makes maximum use of its unique operational capability, if necessary at the expense of its regulatory and other nonoperational roles.					
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PREFACE

This report is submitted under provision of contract No. CG-916668-A with the U.S. Coast Guard to make a forecast of offshore installations to the year 2005. The study is one of several conducted or sponsored by the Coast Guard in an effort to ascertain the likely impact upon the Coast Guard of events between now and the end of the century.

The context of the study is the growing realization that the once abundant resources of our industrialized economy, including space, are becoming less available from their conventional sources on land. This is resulting in a seaward movement of our search for resources, which in turn is impacting upon the environment in which the Coast Guard has traditionally operated, with a significant increase in the demands being placed upon the Coast Guard.

Concurrently with this increased demand, the Coast Guard confronts a period of budget austerity, and in addition is experiencing the constraints of inflation that face all institutions dependent on federal appropriations.

The scope of the study is determined in large measure by the Coast Guard's definition of "offshore installation" to be a structure either fixed to the sea floor or capable of keeping station within a small radius.

The report is in three volumes:

- o Volume I contains a description of the research process, forecasts of the macro and marine environments, forecasts of the offshore installations, implications to the Coast Guard, and the study team's recommendations.
- o Volume II contains detailed forecasts of offshore installations together with the basic data and rationale for their derivation.
- o Volume III consists of a set of appendices: one associated with each of Chapters 2 through 8 in Volume II, and a general appendix.

A

VOLUME II

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11	COAST GUARD ROLES IN OCS
12	OFFSHORE INSTALLATION GROWTH MODEL
	GOVERNMENT FRAMEWORK: AMPLIFICATION

CHAPTER I: INTRODUCTION TO VOLUME II

The purpose of this volume is to present a forecast of the individual elements of the offshore installations (OSI) universe in ocean waters contiguous to U.S. territory through the year 2005. This forecast is focussed on, though not confined to, the effects of endogenous forces in the OSI universe; thus it is complementary to the forecasts of Chapters 2 through 4 of Volume I, which focus on the effects of exogenous forces--those operating out of the macro environment. The forecasts of the individual elements of the OSI universe are presented in Chapters 2 through 9. They form the content of Chapter 5 of Volume I, and form the basis for the assessment of implications to the Coast Guard presented in Chapter 6 of Volume I.

SUMMARY OF CONCLUSIONS WITH RESPECT TO FUTURE OF THE OSI UNIVERSE

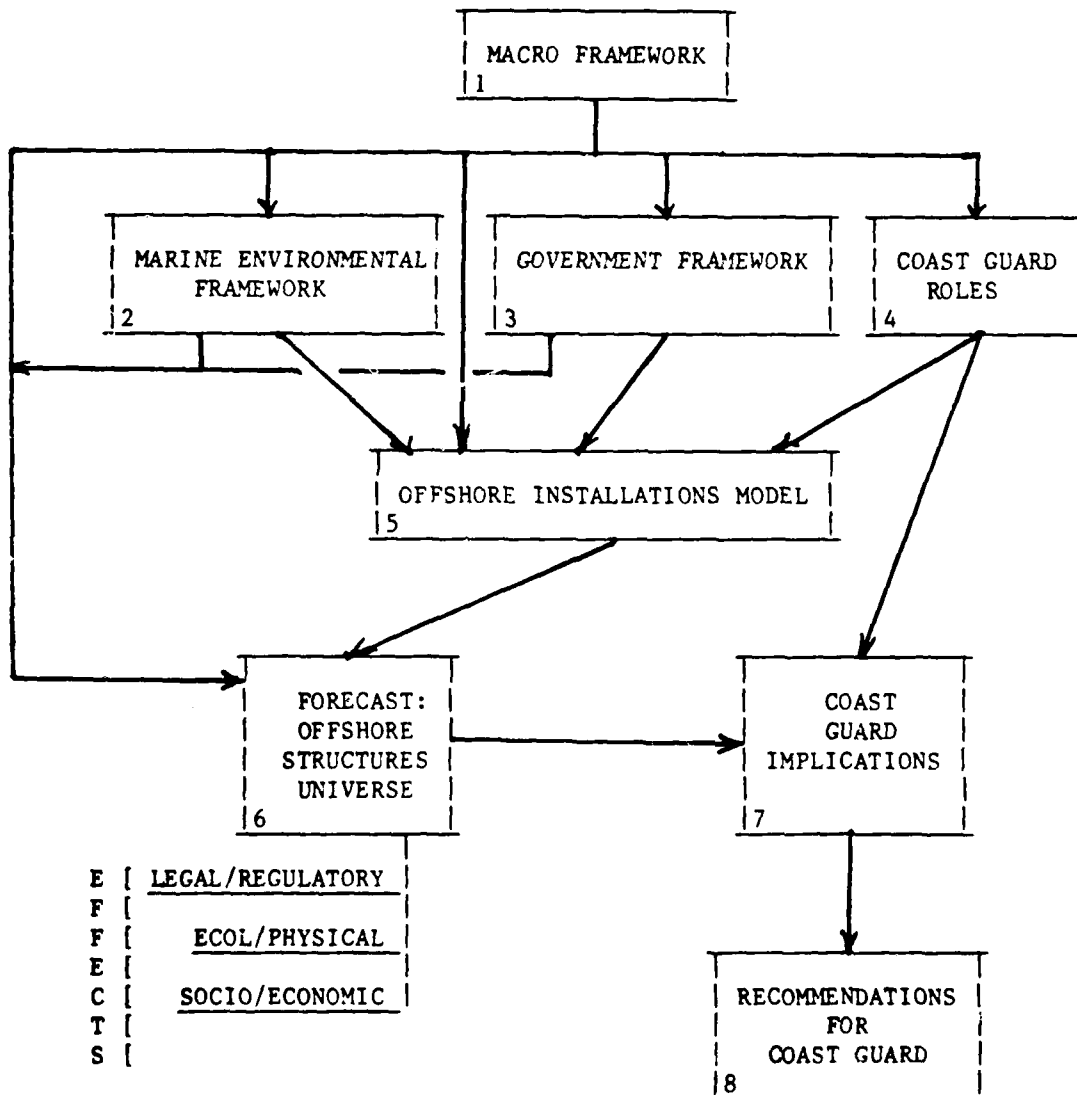
The major forecast of this study for the OSI universe is as follows:

1. By the year 2005 exploitation and extraction of oil and gas will have developed enormously. In comparison, all other developments in the offshore structures universe will be very modest. The only other development of significance will be OTEC. All other energy extraction /production developments will be in various stages of growth, but none will have matured to the same degree as OTEC.
2. By the year 2005 deep water ports will not have grown in number, but will have found substitutes in either special configurations of three-point moorings or an equivalent less elaborate arrangement.
3. The spectrum of OSI future possibilities is defined by the range of possible human decisions. Should a federal administration decree that energy extraction warrants a "man-on-the-moon" effort, the offshore structures universe will expand greatly; on the other hand should successive administrations conclude that the incentives of private enterprise will be sufficient to stimulate the nationally required investment in offshore energy exploitation, then we may expect extremely slow growth.

METHODOLOGY OF STUDY

Figure 1-1 depicts the general work flow and methodology of the study. For convenience it replicates the concept described in Figure 2-3 of Volume I. Volume II presents principally the results of the effort represented by Blocks 3, 4, 5, and 6. Volume I presents the results of Blocks 1, 2, 7, and 8. Both

Figure 1-1
Schematic Diagram of Study Methodology



volumes make use of the work of the foundational blocks, 1 through 3, which are summarized explicitly in Volume I, and selectively extracted for use in each chapter of Volume II.

The blocks of Figure 1-1, together with additional elements of the study, are explained below in a brief description of the conceptual frameworks and model.

- o Macro Framework: the entire universe external to the focus of study effort. It is the combination of scientific, technological, economic, political, and societal developments that set the overall patterns within which all institutions will operate. It provides the structure on which our forecast of global, regional, and national events is constructed. It identifies those variables in the macro environment that either drive or oppose changes in the offshore structures universe or the in Coast Guard--i.e it defines the external forces that determine the future of the OSI universe and of the Coast Guard. Our Macro framework is especially tailored to suit the purposes of this study in that its fundamental structure was developed against the criterion of relevance to the growth of the OSI universe and its relationship to the Coast Guard.
- o Marine Environment Framework: that part of the universe within which the offshore installations are to be embedded and in which the Coast Guard performs its roles. It is the combination of natural and man-related characteristics of the marine environment which ultimately will determine the stage for future Coast Guard mission accomplishment. The structure of this framework was also developed against the criterion of relevance to the growth of the OSI universe and its relationship to Coast Guard mission accomplishment.
- o Coast Guard Framework: a general description of the roles and functions of the Coast Guard, with special focus on their relationships with the OSI universe. This framework provides the foundation on which to assess changes in Coast Guard roles as a result of changes in the OSI universe. These roles are described in Chapter 10 of the present volume.
- o Government Framework: the roles, purposes, and general organizational and structural relationships of world, international, national, and intranational institutions. It depicts the key elements of government that impact on the growth of the offshore installations universe or on the Coast Guard. This framework provides a description of the various actors and their functions that are most relevant to the focus of study. The Coast Guard functions as an integral unit within this framework. As described in this study, this framework focusses on the U.S. federal government, with a secondary focus on state governments.

- o Offshore Installations Operations Systems Model: an inventory of current and potential offshore installations. It represents the structure of the present and imaginable future offshore installations universe. This structure describes the entire range of types of offshore installations that the study team and its Coast Guard associate members were able to conceive could possibly exist in the time frame of the study. It provides a guide to the creative imagination of team members, and stimulates examination of types of structures that could otherwise be overlooked. The interested reader may perceive the possibility of some form of offshore installation not mentioned in the report except in this model. He may then conclude that we have examined the possibility and, rightly or wrongly, decided that it is so unlikely as to warrant no further discussion.

The forecasts of the present volume derive from analysis of the interaction of the elements of these five blocks. More specifically, they derive from our assessment of the manner in which the first four blocks act upon the fifth, in the context of one additional element--the Offshore Installations Growth Model. This model is a description of the general manner in which an offshore installation can come into being both operationally and administratively. The stages through which such an installation is likely to pass in its development from conceptual design to operational offshore unit are described. This description is sufficiently general to apply to all structures being developed under the aegis of the U.S. federal or state governments. The description includes a brief description of the offshore structure growth process as it occurs in the UK also, in order to enrich our perspective. Chapter 11 of this volume presents this model.

Methodological Comments

- o The "obviating factors" are tantamount to forecasts that certain events will not occur. Should they occur, they would be so influential as to render irrelevant the remainder of the forecast/vignette. They represent a "new ball game". They are assessed to be improbable but by no means impossible.
- o The "driving forces" are pressures toward change along the dimensions of change; they do not necessarily relate on a one-to-one basis with the items in the "dimensions of change" column, but in the aggregate they all impact on all the items in this column.*
- o The "barriers" are pressures or inertias tending to impede or inhibit change along the dimensions of change; they are in direct opposition to the driving forces.*

*Economic and technological factors are almost always present as both driving forces and barriers, but they are not listed repeatedly in the tabulation.

- o In our forecasts and vignettes we make no effort to take into account all the possible "eruptions" that could occur; to do so would not only be impossible, but would clutter the study with a mass of individually highly improbable events.
- o The ultimate conclusion as to the effect of sets of driving forces and barriers on a potential change, including the probability of occurrence, and the estimated time of occurrence.
- o The probability of the "most probable" events may not be highly probable; this is easily perceived by thinking of a box of a hundred cubes all of which are numbered differently, except two that are numbered the same. The probability of randomly drawing either of the two with the same number is higher than that for any other cube--i.e. this is the "most probable" event; but this probability is still only 2 in 100.

Figure 2-2 in Volume I following depicts the basic conceptual model for this study. It represents all the possible offshore installations that the study team and its Coast Guard associates could imagine would conceivably emerge with any degree of importance by the end of the time period of this study.

CHAPTER ORGANIZATION: CHAPTERS 2-9

Chapters 2 through 9 of this volume are organized around the major "mission categories" of figure 1-2. These mission categories derive from the OSI Model of figure 1-3, and are defined in such a way as to facilitate our assessment of the impact of (1) external forces on change and growth in the offshore universe, and (2) change and growth in the OSI universe on the Coast Guard.

Each chapter conforms loosely to the following format:

- o Problem statement: brief definition of the purpose of the chapter; description of the problem the chapter is designed to address.
- o Background/Context: salient features of the context in which the dynamics of the mission category interact.

Figure 1-2: Offshore Mission Categories

Mission Categories	Missions
Energy	<p>Oil and gas</p> <p>OTEC Plant-ship</p> <p>Kinetic energy: Current</p> <p> Windmills Solar collectors</p> <p> Tide Waves</p> <p>Deep sea pressure</p> <p>Salinity gradient</p> <p>Seabed geothermal power</p> <p>Bioconversion</p> <p>Coal</p> <p>Fusion power materials</p> <p>Uranium</p> <p>Nuclear and Conventional Power Plants (floating)</p>
National Security and Space	<p>Law Enforcement</p> <p>Land-based Weapons System Interface</p> <p>Threat Identification</p> <p>Space Program Activities</p> <p>Nuclear Waste Storage</p> <p>Support Systems for the Above</p>

Figure 1-2 (cont'd): Offshore Mission Candidates

MISSION CATEGORIES	MISSION
Food Harvesting/Production	<p>Fisheries Management</p> <p>Sea Ranches</p> <p>Fish Migration Tracking Station</p> <p>Offshore Processing of Seafood</p> <p>Agriculture Development</p> <p>Farms</p> <p>Offshore Processing of Seafood</p>
Mineral Extraction	<p>Unconsolidated Deposits on Seabed</p> <p>Sand & Gravel</p> <p>Limestone & Shell</p> <p>Placer Deposits</p> <p>Red Clay/ooze</p> <p>Argonite deposits</p> <p>Manganese Nodules</p> <p>Minerals susceptible to gas/liquid conversion</p> <p>Salt</p> <p>Potash</p> <p>Minerals from Icebergs</p>

Figure 1-2 (cont'd): Offshore Mission Candidates

MISSION CATEGORIES	MISSION
Industrial Development/Seaward expansion of Urban Systems	Industrial Islands Manufacturing--Raw mat'ls frm sea Energy intensive mt'l Raw material storage Airports
Transportation	Transshipment Ports Artificial Islands Deep Water Ports Single Buoy Moorings Logistics Support Craft Submarine Power Cables Submarine Communications Cables Pipelines Pipe Laying Techniques
Recreation/Conservation	Artificial Islands/Offshore Platforms Artificial Islands; Marshes; Land Extensions Underwater Chambers; Offshore Hotels Restaurants; General Maritime Recreation
Research, Navigation Aids, Environmental Control	Satellite Tracking Weather Monitoring Oceanographic Research Radio Navigation Long Range Aids to Navigation Short Range Aids to Navigation

- o Operational System: description of the general operational stages which form the mission category. It is these generic operational phenomena on which the driving forces and barriers to change, emanating from the macro environment, impinge.
- o Geography: the general regional distribution of the mission category activities.
- o Tailored Forecasts:
 - the study team's assessment of the impact of external forces for change on each operational stage of the mission category through the year 2005.
 - a tabulation summary of driving forces, barriers, and obviating factors acting to produce changes along the "dimensions of change".
 - the Tailored Vignette--a future view of each offshore structure type out to the year 2005; indicates both probability of occurrence and the expected time period of occurrence. This vignette is presented in both prose and tabulation form.
- o Appendix:
(packaged separately in Vol III) basic data and detailed rationale underlying the tailored forecasts and tailored vignette; organized to match the "missions" of figure 1-2 and the basic components of the tailored vignette.

CHAPTER 2: ENERGY

Offshore structures associated with extraction or conversion of energy from the oceans constitute the vehicles for performing three functions:

- o Extraction of materials from the sea, seabed, or beneath the sea bed to serve as sources of energy--traditional fossil fuels or nontraditional organic materials.
- o Conversion of the heat, chemical, or kinetic energy of natural forces operating in the marine environment--solar, wind, current, etc.
- o Provision of structural support bases for production processes--either production of energy itself from its ocean sources, or production of energy-intensive products, like aluminum or ammonia.

The following table indicates the types of energy systems with which we are concerned in this chapter.

ENERGY SOURCE	PRODUCTION SYSTEM
Fossil fuel	Oil and gas exploration and extraction
	Coal exploration and extraction
Nuclear	Uranium exploration and extraction
	Fusion fuel extraction
Bioconversion	Kelp and other living energy resource
Solar	OTEC units
	Solar collectors
Natural marine forces	Windmills
	Ocean currents
	Wave energy
	Tidal movement
	Salinity gradients

ENERGY SOURCE

PRODUCTION SYSTEM

Natural geological
forces

Plant site

Ocean hydropower

Deep sea pressure p er

Seabed geothermal energy

OTEC power plant

Nuclear power plant

Oil/gas refining/production

Coal processing/production

Other industrial processing plant

BACKGROUND

Since World War II the world energy picture has been developing certain characteristics of relevance to this study.

- o The demand for fossil fuels has continued to rise.
- o As the limitations in availability of oil and gas have become more apparent, interest in coal has increased.
- o The market mechanism of price increase is gradually rendering attractive what were formally uneconomical reserves.
- o Nuclear power plants have grown in number and in the number of nations putting them to use.
- o Attention is rapidly increasing to development of renewable energy sources, and to sources that are less damaging to the environment than are the fossil fuels.
- o Substitutes for fossil fuels are not likely, in the short run, to replace these fossil fuels in the supply demand picture, but rather to supplement them as demand continues to increase.
- o The sociological and institutional changes required to accomodate the introduction of these renewable energy sources will be significant, and are only beginning to be perceived.

The decade of the 70's constituted a turning point in the industrial development

of the advanced industrialized nations in general and of the U.S. in particular. This decade capped the process by which the U.S. became oil-import dependent for the first time in history. The crisis of 1973-74 was perceived by some to be an isolated incident, but in reality was only symbolic of a process whose roots went far back in time, and whose significance will impact on the U.S. in increasingly stark terms as the decade of the 80's unfolds.

The fact of oil-import dependence is significant in itself, but an even more significant aspect is the nature of the Middle East--the relatively unstable and politically volatile region from which the bulk of our oil comes. This dependence invites risk of economic disruption from either supply interruption or capricious price maneuvering by the OPEC nations.

A consensus among "experts" yields the sobering conclusion that neither intensified domestic exploration nor advanced technology offer significant contribution to reducing our short term dependence on imported oil. At the same time, these experts acknowledge that the oil resources of the globe are nearing long term depletion.

The result is intensified attention to the energy resources of the marine environment. This attention is focussed in the short run on the fossil fuels oil and gas, and in the long run on the numerous other energy sources enumerated in the table on the previous page.

Three important factors appear to be operating in the U.S.'s effort to meet the oil-import dependence problem. First a major avenue toward resolving the problem appears to be conservation; but conservation is possible only from the decision of the populace at large--i.e. is not amenable to explicit policy decision of a formally constituted political body. This means that the controllability of a federal policy of conservation is minimal; it depends on

how effectively the government can persuade. The second factor is that while the oceans promise vast energy resources, in order to tap these resources massive capital investment is required--in magnitudes possible only to the very large corporations, to government itself, or to some combination of the two. The third factor is that the emphasis is on the short run; the problem is perceived to be an immediate one, and while long run solutions are crucially important, the short run considerations dominate present policy.

So the focus on energy in the marine environment has three dominant characteristics:

- o Its policy manifestations originate in the federal government;
- o It is heavily oriented toward reliance on U.S. industry--particularly the oil and gas industry.
- o Its heaviest emphasis is toward short run considerations.

Many of the questions involved in the exploitation of ocean energy reserves, particularly questions as to which alternative conversion systems will be developed in what time frame, are directly related to statutory and administrative mandates to develop domestic sources of energy, especially oil and gas. The degree to which some mix of alternative ocean sources might ultimately help toward large scale development depends on a number of variables. Most of the variables relate to evolving federal policies toward encouraging energy conservation, development of alternative sources, promoting the research and development of nonconventional energy systems, and the final amount of onland and offshore oil and gas reserves the nation has that can be economically exploited.

It is conceivable that a change in any of these variables would change the present federal mandate and result in either deemphasis on developing offshore resources, an emphasis on developing only offshore oil and gas, or an emphasis only on alternative offshore sources. The following are trends in American

energy sources which will help shape the final resolution of the variables influencing the development of offshore energy sources.

Oil and Gas

DOE feels that large quantities of oil and gas still remain in inland U.S. deposits. According to the U.S. Geological Survey, estimated amounts of undiscovered crude range from 31 billion barrels (95% probability) to 81 billion barrels (5% probability). Where within that range actual reserves fall will be very important to the priority time frame of development of ocean resources.

Production of domestic crude oil reached its historic peak in 1970 and then declined sharply. Because of production from Alaska's north slope fields this decline has reversed slightly, but production from that area is expected to crest by 1990. DOE's National Energy Plan (1979) projects that the total domestic production of crude, including both onland and offshore fields, will be 10-11 million b/d in the year 2000.

Domestic production of natural gas has followed the same pattern as crude oil. The natural gas output peaked in 1973 and then declined. But unlike oil, natural gas imports amount to only 5% of total U.S. consumption. Present federal policy aims at stimulating domestic production by raising the regulated price of the product and allowing for deregulation by 1985. So far that policy has resulted in increased supplies of gas.

Coal

U.S. coal reserves are estimated to be 1.7 trillion tons. However, of that estimate, only about 438 billion have been identified with certainty and with enough economic promise to be placed in the reserve category by DOE. More than half of the identified reserve tonage is located west of the Mississippi River, which will result in a shift of the historic center of the coal industry.

Almost 60% of the known reserves are located on federal lands. Another 20% is dependent on the exploitation of adjacent federal coal for production to be economical.

Production of domestic coal has risen for the last ten years, reaching 689 million tons in 1978. Of the total production, approximately 69% is used for electric power generation, 11% for coking, 9% for other domestic industrial use, and 8% is exported. DOE estimates that production will continue to go up, reaching 1.348 billion tons by 1990. U.S. consumption of coal is projected to grow at an annual rate of 5% to 1990. The rate of growth is expected to occur primarily in the electric utility sector, although production of synthetic fuel from coal is also projected to grow rapidly.

Hydroelectric

In 1937 hydroelectric plant accounted for as much as 30% of the nation's total electric generation. By 1977 that percentage had declined to 12%. Although hydroelectric power is fairly safe, low in cost, does not use fuel, and is nonpolluting, its expansion potential is limited because most appropriate sites have already been exploited, and expansion of existing utility sites has been blocked on environmental grounds.

Nuclear Power

Nuclear power plants, held in the 1950's as the savior of American energy, are presently cost competitive with coal plants in most U.S. regions. Seventy-one nuclear plants are currently operated in 26 states and a total of 90 nuclear plant licenses have been granted, although only 45 of those are in the active planning stage. There are, however, a number of uncertainties in nuclear power development, not the least of which will be the outcome of the current strident debate about their safety.

Solar

At present the most promising source grouped under the rubric "solar" (which includes offshore sources) by DOE is biomass. That source is expected by DOE to displace from 3.1 to 5.4 quads per year of conventional energy by 1990. These estimates, plus modest displacement estimates for the other onland solar categories--agricultural and industrial process heat, wind energy conversion, photovoltaic conversion, and solar thermal conversion--would be higher if one assumes a maximum technically feasible expansion of U.S. solar energy use. At present there is insufficient data to know what kind of technical push in solar development can be assumed.

Other Alternative Sources

Geothermal:- There are three types of geothermal energy: hydrothermal, geopressure, and "hot dry rock". These resources may hold the promise of making a major contribution, but many of the processes are still experimental and hold little hope of being commercial until after 2000.

Oil shale:- Very high grade deposits of oil shale in the western U.S. may contain as much as 600 billion barrels of oil. Perhaps another 1.2 trillion barrels may be located in lower grade deposits. However, unless there are significant technological breakthroughs, shale oil will not be cost competitive with oil and gas until their prices rise considerably.

Conservation:- The most efficient use of energy, conservation, is itself a variable that may be of significance for offshore energy development equal to any of the sources already mentioned. DOE has estimated that even assuming current trends in energy conservation, the equivalent of 11 million b/d could be saved by the year 2000. Further incentives to conserve--i.e. higher prices, energy efficient buildings, tax incentives, etc.--could double that figure.

The identity of further influential variables could depend upon the actual progress of ocean energy resource development.

The long run energy potential of the oceans is also being studied with intensity and investigated with sizable resource allocations. All of the items listed in the table on page 2-1 are potential long term energy sources. Of these, OTEC at the present juncture appears to offer the most immediate promise. It is a distant second to oil and gas, but by the end of the century may contribute up to 2 or 3% of U.S. energy needs. All the other items are at best a still more distant third. As the end of the century nears we may expect that these longer term elements will take on increasing significance and be the object of increasing attention in the resource allocation process. Ultimately our energy-independence may rely heavily on one or more of these ocean elements.

OPERATIONAL SYSTEM

There are stages in the process of acquiring useful energy from the oceans that appear to be common to most if not all of the extraction/development processes. Independent of the particular source of energy, these stages have certain characteristics in common that are susceptible to pressures from external sources, and are thereby susceptible to being systematically forecast. We offer here a brief description of each of these stages. In the next section we offer a discussion of the geographical environment of each of the energy sources.

Extraction/development of energy follows a general functional flow along the following lines, not necessarily always in the same order:

Explore--Discover--Extract--Process/Convert--Store--Transport--Consume

As each of these functions becomes subject to the pressures of political, sociological, economic, and technological change, the function

adapts to these changes, independent of the energy source being exploited.

Exploration:- the process of searching for the energy sources. In the case of oil and gas it involves the geological surveys required to identify promising oil rich regions on the OCS and beyond. In the case of thermal gradients, it involves identification of temperature gradients of sufficient magnitude to warrant exploitation. Oil and gas exploration involves the use of offshore structures; exploration for suitable temperature gradients does not.

Discovery:- the act leading to the conclusion that a suspected source has high probability of being a suitable source. In today's technology most discovery techniques are highly probabilistic--i.e. permit only tentative conclusions that must be verified in the early stages of exploitation.

Extraction:- the process of bringing the energy from its indigenous form to a more manageable form. Only in the years since World War II has technology permitted extraction of significant amounts of energy, and as the extraction effort moves seaward into deeper water the effort becomes increasingly more difficult and expensive.

Processing/conversion:- the action necessary to transform the energy into usable form, such as refined petroleum or electric power. This process is not usually unique to the marine environment, but is likely to be a translation of well-known land-based processes into the ocean environment.

Storage:- the retention of the usable processed energy in a form that permits later use. Like processing/conversion, storage does not usually involve technology unique to the marine environment, but is even more likely to be an adaptation of onshore techniques. The technological problems involved in storing electrical energy is one of the most pressing to confront the industry.

Transportation:- the movement of stored energy to its place of use. This function is technologically straightforward, but in the sea environment presents unique problems relating to large masses and to extreme weather conditions.

Consumption:- the absorption of energy in its final use. In the ultimate sense, this function dictates all the other functions.

GEOGRAPHICAL DISTRIBUTION

The sources of the various types of energy we are addressing determine to a large extent both the availability of the energy form, and the technological and economic feasibility of its exploitation. The determining factors include the political as well as the purely spatial.

Oil and gas are located in the OCS in sedimentary basins. For the U.S. this means concentrations in the Gulf of Mexico, off the coast of California, and off the east coast. Known reserves tend to lie in the shallower waters, but this may be because the difficulty of exploration is less and consequently less is known about the deeper water. Very little is known about the oil and gas resources beneath the sea floor, and only limited knowledge is available with respect to the continental slope and rise.

Coal is much less well understood in terms of its ocean availability than is oil and gas, although coal has been extracted from regions near the UK, Canada, Japan, and Taiwan. The availability of coal to the U.S. is sufficiently great that offshore extraction is unlikely to be economically attractive for some time into the future.

Uranium is suspected to exist in the seabed, but very little exploration for it has taken place to date.

Fusion fuel in the form of hydrogen isotopes is abundantly available in

every part of the oceans. Should fusion power become technologically and economically feasible, its fuel availability would not be a problem.

Kelp and other living energy resources have not been developed to any appreciable degree, but should it prove to be economically desirable, this source could be exploited in almost any temperate or tropical waters accessible to the U.S. It would be likely to prosper in the warmer waters.

OTEC units require temperature differences between surface water and deep water of at least 40° F. This means that the only regions readily accessible to the U.S. for OTEC units are in the Caribbean, Hawaii, Guam, and in the lower portion of the Gulf of Mexico. Since direct transmission of electricity is highly inefficient by cable and can be transmitted for only a few hundred miles, the utility of electricity-generating OTEC units is somewhat limited to offshore regions reasonably close to shore. However, OTEC units that use the produced energy on-site in an energy-intensive production process can be located with more flexibility.

Solar collectors, when they have been proven economically and technologically feasible, may be located at any point in the ocean environment. Their location would be determined principally by convenience to end use. The lower latitudes where absorption of the sun's energy is most efficient would be the more suitable, but depending upon collector efficiency any location with significant periods of sunlight would be suitable. Where technologically feasible, natural forces may be exploited for energy content by such devices as windmills and extractors of energy from ocean currents, waves, tidal motion, and salinity gradients in a large variety of locations. Wind and ocean current and wave motion can be exploited virtually anywhere; tidal movement and salinity gradients may be exploited at a variety of places near shore. Tide motion is most efficiently exploited on a coast where tidal

range is high, and salinity gradients near the mouths of large rivers.

Ocean hydropower, deep sea pressure power, and seabed geothermal energy are still so far from promise in terms of commercial use that much further research and experimentation is required before any assessment can be made as to the appropriate locations for their use.

Plant sites for production of nuclear power, OTEC power, oil/gas refining/production, coal processing, or other industrial production are not dependent upon the location of energy resources in the oceans, but are dependent upon the suitability of environmental conditions. This means absence of heavy traffic, either water shallow enough to permit effective mooring of some kind or the use of effective station-keeping technology, and the effective application of environmental protection technology.

TAILORED FORECASTS

^vThis section is in three parts. The first part presents forecasts relevant to the fundamental stages of the energy extraction/development process (see page 2-8). The second part is a tabulation of these forecasts against the driving forces and barriers operating on them. The third part is our Tailored Vignette. It depicts in detail our estimate of the future of each of the types of energy extraction/development processes being addressed in this report.

STAGES OF ENERGY EXTRACTION/DEVELOPMENT PROCESSES

Exploration/Discovery

New technologies and instrumentation of exploration and discovery will continue to emerge through the end of the century. These will include satellite, seismic, sonic, and physical/chemical technologies. By the end of the century, it is likely that we will have the capability to inventory the earth's resources to an order of magnitude greater precision than we can at this time. The new

technologies will permit assessment of resource grade as well as crude presence or absence. Thus the presently known deposits of oil and gas that have been regarded as uneconomical to exploit, but are now becoming more attractive, will be susceptible to precise assessment. The new technologies will also permit correlation between assessments arrived at through different methods--e.g. correlation of temperature gradient measurements with bottom sediment analysis and with macroscopic surveillance to make judgements as to the likely presence of oil or gas.

A major advance in mechanical engineering to permit drilling in very deep water is likely to occur, thus permitting drilling into the ocean floor, and possibly test drilling for samples even into the deep ocean trenches.

Extraction/Capturing

A large gap exists between the ability to find an ocean energy resource and the ability to extract that resource. The gap widens as water depth increases. During the time period of this study that gap is not likely to close significantly for the nonrenewable resources. This is because the opportunities for exploration/discovery remain open ended and the relevant technologies are still highly promising; so equivalent advances are still possible and likely both in discovery and extraction technologies.

At the present time the technology exist to identify and extract minerals from the sediment at the bottom of alluvial regions, but the ability to accomplish this function without risking environmental damage through extensive bottom turbulence has not been developed. Whether it will be cost effective to pursue development of this capability is doubtful before the end of the century.

However, the renewable energy resources are not so inaccessible, and therefore not as dependent upon the exploration/discovery technologies. A relatively

superficial search reveals the feasibility of exploitation of solar energy or energy from any of the other natural forces of the oceans.

Some of the energy-extraction/capturing advances that are likely to emerge by the end of the century include advances in the following areas:

- o Surface mining rigs
- o Subsurface mining rigs
- o Bottom mining rigs
- o Ocean solar collectors
- o Ocean windmills
- o Extraction of chemical/mineral substances suspended in sea water

Energy Transportation

The blockage of the Suez Canal in the mid 1950's spurred development of the very large tankers--the VLCC's and the ULCC's to transport oil at least cost around Africa. The result has been proliferation of this relatively new type carrier. Our forecast is that the numbers of ULCC's will increase at a rapid rate through the next two or three decades, and then level off at a more modest rate of increase as the century draws to a close. A consequence of the increase in numbers of ULCC's will be the need for facilities to handle offshore handling and storage of oil and gas. For a time the Deep Water Port concept appeared to be the solution of consensus, but experience with the two planned in the Gulf of Mexico has led to the conclusion that some form of single point mooring is more likely to be suitable than the extensive facilities envisaged in a full deep water port complex.

In addition to ULCC for oil we forecast increased use of LNG carriers, but the increase in numbers of these is likely to occur slowly because of the hazardous nature of the substance. If coal becomes the object of national attention as a

major source of energy, large bulk carriers analogous to the ULCC's for oil are likely to emerge. However, this is likely to occur only toward the end of the time period of this study.

An additional possibility is that subsurface cargo carriers will become cost effective. This development is not likely to mature by the end of the time period, but could be visible on the possibility-horizon by that time.

Major innovations in pipeline technology are already underway and will probably continue. Pipelines are and will continue to be major components of oil and gas transportation and storage facility complexes. These pipelines will continue to carry oil and gas, but may be expected to carry coal slurry as well should an offshore coal industry develop.

Power transmission lines are another very important means of energy transportation. Before the end of the century, they will become even more important as the OTEC potential becomes reality and the need increases to transmit power over considerable distances at sea to its onshore consumption systems.

Processing and Conversion

This concept refers to the process of converting energy from one form into a direct application--e.g. operating a train, ship, automobile, truck, factory production line, etc. The physical nature of energy is such that significant portions of an energy supply are lost in each transformation process. For that reason, the number of links between energy in its raw form and its final use tends to be small. A major thrust in energy research will continue to be directed toward developing more efficient energy transformation processes.

The areas of likely technological advance include the following:

- o Internal combustion engine. The state of the art is advanced close to the point of diminishing returns in terms of increasing efficiency. Current research is directed principally in two directions. One is toward producing exhaust with least amount of environmental contaminants. The other is toward developing various new fuels--e g. gasahol and other organic-based fuels.
- o Heat Engine. The conventional closed cycle heat engine takes a warm substance input to vaporize a liquid, then puts the resulting vapor pressure to use to drive a turbine, and finally condenses the vapor through the use of a cooler substance to complete the cycle. The turbine output constitutes the end result of the conversion sytem. Research effort is currently directed toward:
 - Development of heat exchangers with increased efficiency. This will permit production of heat engines with the least possible temperature difference between input and output substances. It would have particularly desirable consequences for the OTEC concept.
 - Development of turbines with high energy-conversion efficiency. This will also promote the capability to use input and output substances with minimal temperature difference. And it will be appropriate for application to OTEC.
- o Fuel cells. These devices produce electricity directly from the burning of hydrogen and the consequent production of ionized H_2O . They are a relatively recent development, and promise a more efficient conversion process than either internal combustion engines or the conventional heat engine. Continued research and development is forecast to produce new conversion capabilities and efficiencies. Fuel cell conversion would be particularly appropriate for use in an OTEC installation.
- o Electric Power Plants. Offshore power plants are attractive because of their environmental cleanliness. However, the power loss usually incurred in the transmission to shore for final use inhibits extensive development of offshore plants except where the distance to final use is reasonably small. Technological advances in energy storage or in power transmission are foreseen to be only gradual during the remainder of the century, but should a breakthrough occur in either area, it would mean a significant increase in the applicability of offshore power generation. A current trend exists toward spreading the use of electricity in lieu of combustion processes in a variety of energy applications; this derives from the environmental cleanliness of electricity, as contrasted with the combustion engine. Should technological advances occur in energy storage for use in land transportation, in addition to those mentioned above, the use of ocean platforms for power generation will proliferate.
- o Heating/Cooling. The application of solar energy that appears at the moment to be the most nearly ready for very large scale commercial application is that of direct solar heating or cooling, especially of water for use in residential and commercial buildings, but also for the heating and cooling of the buildings themselves. The absence of an

ffective energy storage technology limits the utility of this process to geographic regions where direct sunlight is available over a fair portion of a day. However, advances in storage technology will spread the applicability of this energy source.

- o Other Forms of Conversion. These include several forms of energy that have intrigued mankind for centuries--the energy of wind, tide, and ocean currents. They also include forms that appear attractive now that heretofore were expensive compared to the very inexpensive fossil fuels available--such as geothermal, salinity gradients, photovoltaic, tectonic plate, deep ocean pressure, ocean hydropower, etc. At the moment the technology of conversion is not sufficiently developed to render these forms economically competitive with forms already available; however, as the price of fossil fuels continues to rise, these forms will become increasingly attractive.

End Use Consumption.

The dimensions of our forecast for change in this area are slightly different from those of the immediately preceding paragraphs. The drive toward change in demand for energy stems much more heavily from need/desire for consumption--including the "consumption" of manufacturing production processes--than from the need/desire for profit promised by increased productivity deriving from technological innovation. In other words, through the end of the century, the demand for energy is forecast to constitute a stronger driving force toward change in our energy systems than the opportunity for profit. This means that technology-push is less a driving force toward change than is demand for energy; or stated in another way, opportunity-push is less powerful than problem-pull. The manner in which this driving force is likely to operate is described in the paragraphs that follow.

Fossil fuel depletion appears to be inevitable; public realization of this depletion may come soon or late. Depending upon when it comes, demand for energy is likely to change in both qualitative and quantitative character. The short term spectrum of possibilities is broad, and it is multi-dimensional rather than linear. It includes the following five points, which are not mutually exclusive.

- ~ Minimum Preparation. Public and governmental action to meet the fossil fuel depletion may be virtually without discipline. Should this occur the following could characterize the short term future:
 - Little or no limits to the use of energy as long as it can be gotten;
 - Conflict among the minorities of people concerned with the issue, but no concerted action either to conserve or to develop new sources;
 - Energy shortages, price fluctuations, and supply disruptions that come by surprise and lead to societal disruptions and conflicts--making the aggravations of the 73-74 shortage seem mild by comparison;
 - No change in life styles except as dictated by these shortages and disruptions;
 - Societal changes involving massive discomforts to large groups of the population, as the unanticipated disruptions occur.
- o Deliberate transition to post-fossil fuel era. The central theme of this scenario would be a major government-led effort to maintain an energy adequate society. Action would take place to locate and exploit fossil fuel sources, to find alternative sources of energy, and to place these alternate sources into commercial and industrial application as the fossil fuel sources become increasingly depleted. This scenario would be likely to promote maximum development of ocean energy resources.
- o Moderate-to-high emphasis on energy conservation. This approach would follow along the lines of the Harvard Business School recommendations to make conservation the central thrust of energy policy. Some of the features of a society following this approach could be as follows:
 - A major change in transportation systems, reducing drastically reliance on automotive transport and increasing reliance on rail, water, and public vs. private transportation vehicles;
 - Change toward less energy-intensive recreational activities. This would likely entail resumption of more family-oriented recreation, and could affect favorably the preservation of the family as the basic societal unit of our society;
 - Reduction in the use of energy-intense appliances both in the home and in public buildings;
 - Legally imposed restraints on heating and cooling of homes and public buildings;
 - Reduction of manufacturing involving energy-intensive processes; replacement with innovative non-energy-intense processes;
- o High emphasis on energy conservation. This scenario would be similar to that of the previous paragraph, except that it would go farther and include major changes in the design of buildings and communities. New

buildings would be constructed to maximize energy conservation both within the buildings and in the building complexes. Such a scenario would include reduction of single family dwellings, increase in large high-rise apartment buildings and condominiums, virtually all transportation by mass transit means, and significant increase in population density.

Our forecast is that no one of these scenarios is likely, but that some scenario combining many of the features listed will emerge. Although some analysts appear to believe that conservation is not consistent with continued economic growth--and therefore with economic health as we know it--we do not share this pessimistic view; we believe that innovative economic policy making, coupled with strong leadership in educating the public, can lead toward a combination of elements in our energy future that promise economic health, energy availability, and environmental preservation. We do not take the position that such a future is likely in the near-term, because at this juncture it appears to us that the necessary preliminary steps have not been taken; however, we do believe there is a good probability that the U.S. people will awaken to the possibility of this future in due time and will move toward it. The impact on the ocean energy program, and thereby the offshore structures, will be heavy.

KEY DRIVING FORCES, BARRIERS, AND OBVIATING FACTORS

The dimensions of change, the driving forces operating within those dimensions, the barriers to change, and the events which, should they occur, would obviate the driving forces toward change in all dimensions, are tabulated in figure 2-1 on the next page. The section following then amplifies the summary of the tabulation.

Figure 2-1:

TAILORED FORECAST FRAMEWORK: ENERGY

DIMENSIONS OF FORECAST	KEY DRIVING FORCES	KEY BARRIERS	OBVIATING FACTORS
<u>Offshore Energy Sources</u>	Economic growth as deeply embedded value	Strident concern for environment	Decision to move toward the pastoral society & away from energy-intensity
Oil and gas			
Coal			
Uranium	Technological opportunity for energy alternatives--especially offshore	Heavy capital investment costs of offshore energy development	Technological breakthrough in fusion power--or other unconventional power source
Fusion fuel			
Kelp & Other Living Resources			
OTEC units			
Solar Collectors	Short term demand for and availability of energy resources	Uncertainties of profit from offshore investment	Unexpected discovery of vast energy resources in the accessible land environment
Hydropower, Deep Sea Pressure Power, & Seabed Geothermal Power			
Plant Sites			
<u>Exploration/Discovery</u>	Increasing costs of conventional energy	Administrative bottlenecks in offshore leasing processes	
<u>Extraction/Capturing Systems</u>	Depletion of conventional energy sources	Lack of institutionalized processes for exercising rights & responsibilities of ownership and governance in offshore environment	
<u>Energy Transportation Systems</u>	Public fear of nuclear energy		
<u>Processing & Conversion Systems</u>	Need for U.S. energy-independence		
<u>End Use Consumption</u>			
Minimum Public Preparation			
Deliberate Transition to Post-fossil Fuel Era			
Moderate-to-high Emphasis on Conservation		State of deep sea technology	
High Emphasis on Conservation			

The Tailored Vignette

This section presents first our general forecast of the context in which the energy-related offshore structures are embedded--the general environment from which demand for energy producible through these structures emerges. Then the remainder of the section describes our forecast of the particular categories of offshore structures within the energy mission category.

General

1. The energy-intensity of the U.S. economy will continue to increase throughout the remainder of the time period of this study. Energy use may diminish, but only slightly. As a society we will not opt for the arrested growth that some appear to favor. Two factors govern: first is the hope that either our resources are more plentiful than we can foresee, or technology will come to the rescue as it has in the past, or some combination of these two possibilities; and second is the extreme societal pain that regression would entail.

2. The period of this study will be a period of transition toward reliance on different energy forms--forms dependent on renewable energy sources. This transition will not be completed during this period, and most energy use will still rely on current forms--oil, gas, coal, and nuclear. But the direction of the change will be well defined by the end of the period, and science and technology will be focussed toward commercialization of the new forms. Within the ocean environment these new forms will be represented principally by OTEC, with the other natural energy sources at some distance behind. By the end of the period, two parallel energy source systems will underly our economy, one phasing out and the other phasing in. The transition will be neither simple nor easy. The period will be one of frequent disruptions, with contentious issues, as our society adjusts to a new way of operating.

3. The intensity of the search for new energy sources will increase during the time period of this study. Toward the end of the 80's, the military and economic vulnerability of the U.S. will become even more visible. Frequent disruptions to the convenience of the U.S. citizen will awaken him to the reality of "interdependence" and the price it will exact if it is allowed to proceed without constraint. Popular sentiment will support the partnership between the government and private industry in the search for energy resources in the oceans, and some of the administrative bottlenecks that now encumber this partnership will be broken or at least weakened.

4. Advances in technology will enable resource inventories to be made at significantly increased levels of accuracy and confidence. Toward the end of the time period, we will have reduced the uncertainty in our estimates of the availability of energy resources. We will have come to the end of the era in which the belief that "we will always find more" prevails.

5. Generation of electrical power in offshore plants will increase toward the end of the century. These will be principally OTEC plants, but current plans for siting floating nuclear power plants offshore will become a reality, at least to the extent of one or two plants. By the end of the century the potential of the many other ocean energy sources will have become focussed and sorted out to identify those with the most promise--solar, wind, current, wave, tide, etc. Current talk of offshore production of electricity through the use of oil, gas, or coal is unlikely to come to fruition. We perceive this to be born out by environmental regulations that will not stand the test of economic feasibility, when the cost of power transmission is considered.

6. Use of power generated offshore to produce energy-intensive products is likely to increase; OTEC power is likely to be one of the first of these plant-ships. We doubt, however, that other than OTEC power will be so used; the

economics just do not appear to justify it. OTEC plant-ships are likely to be operating that produce ammonia, hydrogen, aluminum, and other energy-intensive products.

Detailed forecasts for the offshore structures in each mission category are presented under the following category headings.

Oil and Natural Gas

1. The search for oil and natural gas in the marine environment will continue at high intensity through the end of the century. The emphasis in this area will dwarf by comparison the magnitude of effort in other activities to develop energy resources in the marine environment. The offshore structures engaged in oil and gas exploration and extraction will greatly outnumber those engaged in any other activity.

2. The regions in which oil and gas exploration and extraction are concentrated will continue to be the Gulf of Mexico, Alaska, off the west coast, and at an accelerating rate off the east coast of the U.S. In the Gulf extension of production into deeper water will continue at an accelerating pace, while the exploration off the east coast will concentrate in shallower water for a time, then move into deep water.

3. Substitutes for oil and gas will remain in development through the end of the century, but they will serve almost exclusively to satisfy additional demands for fuel, and not to reduce the demand for oil or gas. These substitutes will include coal, already being substituted in electricity generation plants, "synfuels", and the more exotic renewable energy forms being sought in the oceans.

4. The rate of increase in demand for oil and gas will significantly diminish by the end of the century; one of the principal factors promoting this diminution will be the growing awareness of the need for mass transit systems

to replace the private automobile in as many ways as possible. An inherent barrier to rapid development of mass transit systems to replace the private car will be an institutional one; the investment in resources and in time required to construct a mass transit system on the scale that would be required would be enormous. This trend could be further slowed by the emergence of an efficient and effective battery for use in electric propulsion of private vehicles.

5. Signs will begin to appear before the end of the century that nonfuel uses of petroleum are expanding. This trend will only be slightly visible by the end of the time period of this study, but will emerge with vigor within the first few decades of the 21st century. As it emerges the demand for offshore oil will not diminish--as one could expect from successful programs to substitute other energy sources for petroleum--but will be maintained at a level sufficiently high to support continued offshore extraction of oil.

6. The density of offshore oil and gas structures will continue to increase, especially in the shallower waters, and will reach the point off the east coast to require acceleration of sea zoning activity. Fareways and traffic safety separation schemes will be extended.

7. Within the territorial waters, where the states have jurisdiction, the states will be encouraged if not forced to take on responsibility for the administration of the offshore activities, including zoning and law enforcement.

8. The OPEC nations will persist in periodic price rises, which will have the effect of making offshore oil and gas extraction economically feasible, perhaps at an increasing rate, throughout the remainder of the century.

9. Environmental issues will continue to inhibit growth of the offshore universe, but will only slow development, not stop it. As the stress of oil and gas scarcity tightens, the influence of the environmentalists will fade.

Their most likely regions of influence will be in the bays and estuaries along the coasts, and these will be increasingly under state jurisdiction. The effect on the offshore universe beyond the territorial seas and on the Coast Guard will be negligible. However, the effect will be to increase the price of oil and gas.

10. As exploration and extraction moves seaward the probability of international tensions and controversies will increase. This will be so especially between nations with contiguous offshore oil fields, but conflicts will also be likely over rights of access between nations who are not necessarily contiguous. A major source of controversy is likely to be environmental protection in circumstances where one nation has quite different standards of environmental protection than another.

11. Some of the major characteristics of oil and gas extraction systems will be as follows:

- o Increased use of semisubmersible rigs as deeper waters are probed;
- o Introduction of bottom-mounted rigs in small numbers;
- o Extended growth of bottom-mounted pipeline networks between offshore complexes;
- o Growth of a variety of types of single-point mooring systems, together with vanishing of the "Deep Water Port" concept as it has existed for several years;
- o Reasonably rapid growth in the capability to find and extract oil and gas adverse weather conditions in general, and from the arctic and antarctic regions in particular;
- o Increased safety and security on offshore structures exposed to hazardous weather conditions;
- o Rapid increase in the capability to find and extract oil and gas from sources in deep water--to as great as 4000 feet and beyond.
- o As energy price rises, economic reserves increase dramatically. See figure 2-2 on the following page.

Coal

1. For the next two decades coal will be of high importance in the U.S. energy picture. It will be used in many ways during that period as a replacement for oil or gas, especially in the production of electric power. By the end of about two decades other forms of energy, including "synfuels", will have been developed to a point that causes coal to revert to a position of somewhat lesser importance. Such a prediction bars a technological advance, such as efficient gasification, which moves coal into a more favorable position than it has enjoyed to now with respect to the environment.

2. During the twenty or so years that coal is of great importance, the mining of coal from under the sea is likely to be confined to that which can be extracted from shafts driven from land bases. The probability of coal shafts drilled from the sea surface, with offshore platforms as the recipient of the product, is low.

Uranium

1. The current conflict over the use of nuclear power is highly likely to diminish in intensity as the need for energy and the utility of nuclear power becomes clear. This will be emphasized in the late 1980's or early 1990's as the failure of the U.S. to anticipate the long lead times required for power plant development and construction manifests itself, and we experience the possibility of an acute power shortage. Yet the aversion to the environmental risks of the breeder reactors may persist and yield uranium a place of importance in the priorities of energy materials. If so, the demand for uranium will increase at least until the opposition to the breeder concept diminishes.

2. The demand for uranium will also be likely to increase if, as expected, the recent period of uranium price rise continues. This price rise will render extraction of uranium from sea water economically feasible before the end of the century. Extraction of uranium from the sea would lead directly to the feasibility of immediate use of that uranium in offshore power production. The desirability of offshore nuclear power plants will thus increase and these plants will take their place in the planning system. However, because of the long lead times required, the probability of construction of such plants in significant numbers by the end of the century is extremely low. This uncertainty is multiplied by the uncertainty in the many other potential energy-related developments now being considered.

3. In addition to power plants stimulated by the above developments, the existing pressure to site nuclear power plants offshore may lead to the location of additional plants offshore by the end of the century. The attraction arises because of the relative cleanliness of these plants, when they are operating normally.

OTEC

1. The federal government and certain state governments are likely to continue their current interest in OTEC development through the next several years to the point of conclusive evidence as to OTEC's feasibility.

2. Our forecast is that OTEC feasibility will be substantiated. We forecast that by the end of the century OTEC will provide a significant portion of the energy for Puerto Rico, Hawaii, Guam, and some of our southern states.

3. We also forecast that because of the high cost of energy transmission over long distances, OTEC plant-ships will become highly cost effective means

of putting OTEC energy to use. We forecast that by the end of the century a dozen or more such plant-ships will be in or near operational status. These plant-ships will produce aluminum, ammonia, hydrogen, or other energy-intensive manufactured product.

4. By the end of the century the technology of power transmission will also produce the capability to transmit power over longer distances than is now cost/effective (see section below on Energy Transportation). This development will have the effect of fostering the growth of OTEC offshore structures.

Other Energy Sources

A number of other potential energy sources are under study and offer promise in the more distant future beyond this study's forecast period. None of these energy sources is highly likely to reach the stage of commercial application by the end of this time period, but the possibility is not negligible. A technological breakthrough could occur on short notice that immediately brings any one or a combination into operational feasibility. Should this occur, the offshore structures universe would be enlarged. Therefore research and development in each of the following areas should be closely watched.

1. Offshore Solar Collectors.

- o Direct extraction of energy from the sun's radiation is likely to be extensively commercialized for use on land within the next few years. Its most common use will continue to be in heating and cooling, but extension to other uses through application of the technology of photovoltaic action is likely to occur.

- o Extended construction of solar collectors on floating platforms at sea for the generation of power for further transmission to land use is unlikely; however, use of solar radiation for heating and cooling of the facilities mounted on offshore structures is quite probable.

2. Offshore Windmills

Although considerable research into the feasibility of offshore windmills has been conducted with the emergence of a strident school of supporters, the establishment of large banks of windmills on offshore structures for supply of power to shore needs is unlikely by the end of the century.

3. Geothermal, Salinity Gradients, Ocean Current, and Deep Sea Pressure Power

Each of these potential sources has potential, but this potential is not likely to emerge into commercial application at any time before the end of the time period of this study. This is again not to say that it could not--just that it is not perceived as likely at this time. Our forecast is that the offshore structures universe is unlikely to be affected by these developments by the year 2005.

FIGURE 2-3: TAILORED VIGNETTE - ENERGY

FORECASTS	PROBABILITY/TIMING		
	1985-1990	1991-1997	1998-2005
OIL & GAS PRODUCTION WILL PEAK & LEVEL OFF	M	H	L
OIL & GAS PRODUCTION WILL BEGIN DECLINE	L	M	H
OTEC ENERGY WILL PROVE ECONOMICALLY & TECHNOLOGICALLY FEASIBLE	H	H	H
OTEC ENERGY WILL BE A SIGNIFICANT PORTION OF U.S. POWER IN GULF & ISLAND ECONOMIES	M	H	H
COAL PRODUCTION WILL BECOME SIGNIFICANT	L	L	L
URANIUM EXTRACTION WILL BECOME SIGNIFICANT	L	L	L
FUSION POWER WILL OBLVIATE THE ENERGY PROBLEM	L	L	L
OTHER FORMS OF RENEWABLE ENERGY FROM THE OCEAN WILL PROVE ECONOMICALLY AND TECHNOLOGICALLY FEASIBLE; and	M	M	H
WILL PROVIDE SIGNIFICANT AMOUNTS OF POWER	L	L	L
THE ECONOMIC & TECHNOLOGICAL FEASIBILITY OF ENERGY-INTENSIVE MANUFACTURING IN OFF-SHORE INSTALLATIONS WILL BE DEMONSTRATED	L	M	H
and			
WILL BECOME OPERATIONAL	L	L	L

H = High; M = Moderate; L = Low

CHAPTER 3: NATIONAL SECURITY

By the term "national security" we mean the state of the nation in relationship to either internal or external threats to the physical or psychological well-being of its citizens and their possessions. Concerns for national security can lead either directly to development of offshore structures, or to activities related to these structures--i.e. activities in, on, beneath, or around them, or in some other way related to them. The purpose of this chapter is to describe

- o Offshore structures likely to be constructed as a direct result of national security considerations; and
- o Activities in the OSS universe likely to result from national security considerations.

National security considerations can lead to events or activities of the following nature associated with the OSS universe:

- Law enforcement
- Land based weapons interface
- Protection of life, property and the environment
- Space program activities
- Nuclear waste storage
- Threat identification
- Support systems for the above

As will be seen later in this chapter, only the support activities and sensors for threat identification are likely to lead directly to the construction of offshore structures; all the other categories lead instead to activities related to already existing structures--activities which are nonetheless highly relevant to the Coast Guard and which may dictate some of the characteristics of the offshore structures themselves in order to insure maximum national security.

BACKGROUND

The following factors represent national security considerations impacting on the OSS universe:

1. The nuclear weapons power of the "great powers" provides an umbrella under which the nature of military action has changed. The graduated use of lower levels of power has assumed increased importance, not when used by great powers against great powers, but when used by or against the lesser powers.

2. Technology is widening the spectrum of opportunities for the use of lower levels of force. The great powers feel compelled to maintain a state of readiness at all levels, and thus the expense to them of readiness has increased more than commensurately with technological advance.

3. The number of nations with capability to damage/threaten the U.S. has increased; in addition, the number of non-sovereign political bodies--i.e. organized political groups of nonnational origin--with the power to threaten has also increased.

4. The U.S. has continued to perceive U.S./U.S.S.R. parity as a matter of highest importance; it means maintenance of readiness at the most sophisticated levels of violence, at the expense of readiness at the lower levels. This has led the U.S. Navy to specialize in highly sophisticated weaponry at the expense of readiness at the lower levels.

5. The U.S. has continued to maintain a "great power" role with its attendant need to be prepared to handle any form of threat at any level. The "great power" role and the "readiness at all levels" role are thus in conflict.

6. Weapons technology has advanced to the point that defense against the highly sophisticated weapons of the U.S.S.R. requires ship weapon suits of a highly specialized nature, and of a nature not suitable for use in a variety of smaller scale combat actions. U.S. Navy ships are equipped with these more sophisticated weapons suits, and not with weaponry adaptable to small scale action--e.g. action against small craft engaged in relatively minor law violation, or against sabotage operation against an offshore oil rig. Thus the overlapping military capabilities of the Navy and of the Coast Guard has largely been

eroded as a result of the Navy's strong effort to maintain defense against the most sophisticated Soviet weapons. This leaves the Coast Guard as the only U.S. operating military force with the capability to use force at the lower levels of sophistication in violence. The disparity between Coast Guard capability and Navy capability has widened to the point that the Coast Guard is the sole agent of the federal government with capability to defend the OSS universe against many of the more probable types of threat to it in the remaining decades of the century.

7. As the economic assets of the U.S. in the ocean environment increase in numbers and in value, the role of our national security forces in protecting these assets increases. These "assets" are virtually all concentrated in or on offshore structures in some form.

8. As the offshore assets of the U.S. increase, the OSS universe becomes a vulnerable target of opportunity for nations hostile to the U.S.

10. Maritime traffic in illegal drugs and illegal aliens continues to expand. As the number of structures in the OSI universe continues to grow, that environment has the potential of being a secret haven for traffickers, and its related traffic patterns have the potential to cover illegal traffic.

11. As global "interdependence" increases, the variety in the forms of potential conflict also increases. For example, one of the more recent developments has been new and sometimes ingenious ways of taking and holding hostages. The potential exists for significantly more grandiose aspects of hostage taking and holding. Many elements in the OSI universe are vulnerable. Terrorists could board an offshore oil rig and plant a small nuclear weapon, with the threat to destroy the rig and many others in the vicinity. This issue has been addressed in the open literature and is controversial, with many claiming that the value of the asset is not likely to be sufficient to warrant this risk by

... a' ersary. However, even if the probability is low, it would seem to warrant some form of preparation by the interested parties.

12. As nations become increasingly aware of the resources available in the marine environment, and as the beneficial effects of these resources begin to be evident (especially on the economies of the advanced industrialized nations), the resource-poor nations are beginning to make conflicting claims over space and use in the marine environment. These conflicts have the potential for creating violent action in the OSI universe. In the event these conflicts mature into physical action, the Coast Guard role is either to contribute to defense of these assets, engage in some form of search and rescue, or accomplish environmental clean-up.

13. The pressures to dispose of the waste products of shore-based nuclear power plants has the potential to result in placement of nuclear waste disposal sites in the marine environment--perhaps deeply embedded in the ocean floor.

14. By far the greatest rate of increase in numbers of offshore structures has been in oil and gas exploration and extraction units. Thus the geographical distribution of the increasing population of offshore structures is in those regions where oil and gas is likely to be found. (See Chapter 4 for discussion of this distribution.)

THE NATIONAL SECURITY OPERATIONAL PROCESS

The strategic and tactical stages of the process by which national security is preserved can be approximated as follows:

- o Surveillance. This includes intelligence collection and processing in all of its forms; operationally it focusses on instrumented observation of a geographic region for the purpose of discovering activities of a questionable nature.
- o Detection. The reception of a signal indicating an activity of questionable nature. This may be by satellite, radar, sonar, photographic, or by human visual or acoustic observation.

- o Threat Assessment. Determination through an analytical process of the probable threat to national security of the signal detected. This process invariably involves analysis of a complex of signals in the total context of the surveillance function.
- o Action Decision. The decision by the commander of security forces to take action to neutralize or minimize the threat, or to establish and maintain close surveillance over the detection area for some further time period.
- o Interception. Movement of "friendly" forces to the area of detection or area of probable threat with the intent to place these forces into position to neutralize or destroy the source of threat.
- o Action. Action taken to neutralize or destroy the source of threat. This action may be investigation, containment, arrest, capture, physical removal, crippling or destruction, or any other action decided upon for this purpose.
- o Administrative Follow-up. The required legal and other administrative action required of a military or law enforcement agency to carry through the intent of the law and of the commander's decision to act.

Underlying all of these functions are the support functions of logistics, training, research, development, test, and evaluation. As will be seen in the pages that follow, these support functions lead to construction of offshore structures, whereas the other operational functions are more likely to lead to activities in, on, or around already existing structures.

GEOGRAPHIC DISTRIBUTION

The principal offshore structures constructed solely for use of defense forces are concentrated now and likely to be in the future in the waters where the climate is propitious for training and space flight tracking of missiles or space craft --i.e. the Caribbean and off southern California and Hawaii.

TAILORED FORECAST

This section contains a forecast of developments in each of the functions described in the section preceding on the operational defense system.

Surveillance.

Technological advances will lead to increased capability for surveillance. Geographic coverage will be increased through increased electromagnetic and acoustic power radiation capabilities of sensors.

Advances will also lead to increased capability for analysing incoming signals in surveillance equipment.

Integration of on-line surveillance data with intelligence data will be improved. This will permit more reliable interpretation of surveillance data.

Over-the-horizon radar technology will add to surveillance capability.

Research in identifying electromagnetic or acoustic "windows" in sea water have low to moderate probability of yielding improved capability for underwater surveillance.

Detection.

The capability of sensors to identify and track targets will improve through advances in range resolution, and bearing and elevation discrimination of electromagnetic and acoustic sensors.

The technology for processing tactical data will improve the capability of automatic tracking systems to maintain tracks on evasive targets, through the use of second and higher order derivatives in the computational process.

Ability to track through noise from interference, static and weather conditions will increase.

Sensor capability will increase in terms of range, types of radiation in use, and discrimination among types of targets.

Tactical data processing equipment will be improved in its capability to maintain tracks on multiple targets.

Threat Assessment.

Command communications and control (C³) equipment will be improved to enable operational commanders to perceive a total tactical picture with increased confidence. Satellite systems will be integrated into C³ systems in furtherance of this objective. The result will be more positive control of tactical forces in an operational circumstance.

Action Decision.

All of the foregoing will give an operational commander an improved ability to make decisions as to the most appropriate action against a threat to national security.

Interception.

Advances in microminiaturization of electronics components will lead to increased ability to deliver manned or unmanned sea or air born units to points of interest rapidly and accurately.

Technological advances in propulsion and in vehicular modes will advance ability to deliver effective units on scene. Air cushioned vehicles, hydrofoils, V/STOL aircraft, and vehicles with near-invisible electromagnetic and acoustic signatures will also enhance this capability.

On-Scene Action.

Payloads will be improved in terms of design for discriminate use in specific purposes. All-weather investigation capability will be improved, as will the capability to contain and remove oil and other pollutants from sea surfaces. Advanced instrumentation incorporating chemical, holographic, or other techniques will augment direct inspection as a method of investigating vessel contents. The ability to incapacitate a ship with precise control will be developed.

Administrative Follow-up

Integration of operational systems with intelligence systems will facilitate the efficiency and effectiveness of follow-up action. Unnecessary investigation will be reduced, while the number of actual target interdictions will be increased. This will reduce administrative back-log, and render the entire system more credible, increasing the deterrent effect.

General Observation

All of these trends will contribute to improved operational capability for protection of offshore assets. Even though the relevant technologies will be available to adversaries, the technological superiority of the U.S. will remain clear enough to give the U.S. forces the advantage during the forecast period.

Support Systems

Logistics systems directly supporting any of these military or quasi-military functions are not likely to be constructed; however, systems for training, research and development, as well as test and evaluation systems will be established.

Figure 3-1 depicts the dimensions of our tailored forecast, with the operational driving forces, barriers, and obviating factors. The items listed as driving forces, barriers, and obviating factors are not tabulated to correspond directly with the "Dimensions of Forecast" items in the left column, but rather are meant to relate to the entire concept of increased activity to neutralize threats to the U.S. in general, and to the OSI universe in particular.

The Tailored Vignette

Instruments of National Security and Their Roles--A Forecast

There are basically two instruments of national security: the military services

and law enforcement agencies. The U.S. Navy and the U.S. Coast Guard, supported of course by the Army, Air Force, and Marine Corps, constitute the principal elements of the former in the OSS universe. The Coast Guard is the principal operating element of the latter, augmented by the INS, the Customs Service, and the Department of Justice (FBI and DEA).

The roles of military and law enforcement forces in the OSI universe include: promotion/protection of its natural growth; defense against hostile acts; and regulation of its growth to insure compatibility with the laws and customs.

The following forecasts describe the context within which the OSI-relevant national security process is expected to function during the period of this study.

1. National sovereignty will remain a fundamental value among nations. "One world" proponents will continue to be heard, but will not bring about major changes in the manner in which nations relate to each other.
2. The world will continue its trend toward multi-polarity. This will lead toward proliferation of both nuclear and non-nuclear military power among nations. The nuclear umbrella will continue to represent a constraint within which the "great powers" operate; they will be increasingly susceptible to aggressive "tweaks" from the lesser powers. The latter will carry out such actions with a degree of impunity. "Parity" among the great powers will continue to be sought, but will remain ill-defined, and not confined to "nuclear parity".
3. Sincere efforts to limit the arms build-up will continue, with some success, but without an overall "outlawing" of military force as an instrument of policy--or even of reducing it beyond its present level.
4. The U.S. and the U.S.S.R. will continue to aspire to perform their

"great power" roles, but with diminishing effectiveness as other nations challenge them for power status positions.

5. Defense will remain a large proportion of the U.S. budget, although it will vary cyclically. The Coast Guard will continue to lag in receiving its share of the federal budget in terms of its ever-increasing roles and responsibilities in the ocean environment.

6. A major factor in the Navy's operation will continue to be the opacity of sea water; a breakthrough is unlikely in identifying a "window" for either electromagnetic or acoustic radiation.

7. The space program will continue at approximately its present level of effort.

8. The U.S. economy will continue its slight trend downward, but will maintain sufficient strength to allow defense allocations at approximately the level of the 70's or even slightly above this level.

9. The problem of handling nuclear power plant waste will continue to plague the federal government; authorities will give consideration to assigning the military services--the Navy in particular--responsibility for developing and executing disposal processes. One option will be disposal in deep sea trenches, with suitable safeguards for radiation containment.

10. The most probable form of military activity in the marine environment adjacent to the U.S. will be relatively low level anti-social action. This may take the form of terrorist activities, sabotage of offshore assets, or hostage taking of these assets or the personnel stationed on them. Some aggressive action may take the form of subsurface approaches to the offshore assets.

11. Illegal traffic in drugs and aliens will be the principal form that non-destructive law breaking will take. The violators will use the offshore

Figure 3-1: TAILORED FORECAST FRAMEWORK: NATIONAL SECURITY

DIMENSIONS OF FORECAST	KEY DRIVING FORCES	KEY BARRIERS	OBTAINING FACTORS
<u>Surveillance</u>			
Intelligence Collection	Increased value of offshore assets	Technological*	Success of SALT or other disarmament effort
Electromagnetic Instrumentation	Perceived increase in propensity to use terrorism or hostage taking as mode of international persuasion.	Economic*	U.S. isolationism coupled with drastic reduction of USSR & PRC military capability--for whatever reason.
Acoustic Instrumentation	Technological opportunities*	Political feasibility	Discovery/development of vast and renewable/inexhaustible reserves of energy resources not requiring offshore structures.
Satellite Instrumentation	Increased traffic in illegal substance & aliens.	Slowness in build-up of offshore assets	Technological breakthrough in making sea water transparent to surveillance in some form
Other forms of Instrumentation--security alarm systems, chemical sensing, olfactory sensing, etc.	Prospective confluence of seaward movement of U.S. economic activities with those of other nations.		
<u>Detection</u>			
Intelligence			
Electromagnetic			
Acoustic			
Satellite			
Other			
<u>Threat Assessment</u>			
By automated tactical data system			
By manual (non-automated) analysis			
*Technological opportunities, and technological and economic barriers are operative in all "Dimensions of Forecast" tabulated here, and will not be repeated in this tabulation.			

Figure 3-1: TAILORED FORECAST FRAMEWORK: NATIONAL SECURITY

DIMENSIONS OF FORECAST	KEY DRIVING FORCES	KEY BARRIERS	OBVIATING FACTORS
<u>Action Decision</u>			
Automated C ³ system			
Manual C ³ system			
<u>Interception</u>			
Cutter/ship			
Aircraft--fixed wing/helo			
Boarding			
Missile/projectile			
Submersible			
<u>Action</u>			
Destruction			
Non-destructive neutralization			
Incapacitation			
Investigation			
Containment/removal			
Arrest/seizure			

Assumption by the states of responsibility for protection of assets within the three mile limit. (This will obviate only federal government action to provide for this protection, but will not obviate the need for the protection.)

Figure 3-1: TAILORED FORECAST FRAMEWORK: NATIONAL SECURITY

DIMENSIONS OF FORECAST	KEY DRIVING FORCES	KEY BARRIERS	OBVIATING FACTORS
<u>Administrative Follow-up</u>			
<u>Logistic Support</u>			
Facilities			
Craft--air and surface			
Materials--fuel, food, supplies			
Personnel			
<u>Training</u>			
Instrumentation			
Range facilities			
Simulation facilities			
Operating areas			
<u>RDT&E</u>			
Range facilities			
Instrumentation			
Analysis facilities			

structures as means of cover as well as vehicles of conduit; and they are likely to use the traffic patterns among the offshore structures to cover their movements.

Operational System Components--A Tailored Vignette

The following forecasts of operating system components is based upon all of the foregoing plus the detailed data included in the appendix to this chapter.

Weapon Target and Space Program Range Structures

For the remainder of the century use of these structures will increase gradually as weapons technology advances and other less sophisticated means of tracking weapons flights become less adequate. Technological advances in instrumentation will lead to increasingly advanced technologies for use in these structures, but spill-over into non-military uses is not foreseen.

Expansion of ranges is likely, but no trend is foreseen to increase the number of ranges. However, since these ranges are placed geographically to offer least interference with traffic and other economic activities, this expansion should present minimum problems to non-military users.

Military and space range structures will continue to be constructed and the technologies in use by them will continue to advance. However, the number of structures is not likely to increase significantly by the end of the time period of this study, and the relative importance of these structures in the OSI universe is not likely to increase significantly. These structures are likely to be constructed in tropical or near-tropical waters where the weather is favorable.

Acoustic Surveillance of Broad Ocean Areas

There have been no technological breakthroughs sufficiently important to lead to either a drastic increase or decrease in the use and coverage of SOSUS units over the past decade; and the acoustic properties of the ocean are sufficiently understood that a quantum jump in use or coverage is unlikely during

the period of this project.

Each SOSUS installation is expensive, so budget limitations have prevented as full a coverage as the Defense Department would like.

The military need for SOSUS units will persist throughout the time period of this study, so as funds become available, gradual increase in the number of arrays and in geographic coverage will occur.

Readiness and Launch Positions for ICBM Weapons

The probability of significant numbers of installations before the end of the century is not high; however, the decision to initiate such a weapons complex can be made by a highly centralized authority--the President in consultation with the Secretary of Defense and the Joint Chiefs of Staff--so changes in international tension could lead to sudden changes in the outlook.

Should such facilities be installed, they would be likely to be built on the Atlantic OCS, with secondary locations in the Pacific.

In summary, sea bed silos will be under serious consideration toward the end of the century, but none will be installed or under construction by that time.

Safe Storage of Nuclear Waste Products

Although safe deep sea nuclear waste storage has been subject to discussion for some time, and although such a development could, in fact, help resolve the nuclear waste disposal problem, the expense of drilling to the depths required, and the unproven technical feasibility of guaranteeing absolute safety are likely to militate against that action for many years.

This endeavor, like seabed silos, will be under serious consideration by the end of the century, but no waste disposal sites will have been established by that time. Our rationale for this position is described briefly as follows.

The general nuclear waste problem in the U.S. both now and in the year 2005 will be the containment of radioactivity. This will involve the safe transport, storage and treatment of spent fuel elements and the resulting high radioactive wastes which remain active for centuries. Nuclear waste must be stored in permanent and "leakproof" facilities. The only way to neutralize the nuclear waste is to allow its decay.

Currently, spent fuel elements are disposed 40 feet deep in metal-lined storage pools in licensed storage areas. The waste is pumped into these pools and covered by 20 feet of water. This is termed "temporary" storage; the spent fuel is to remain there until "reprocessing" operations begin. There is currently no "reprocessing" going on. High level wastes are of very small volume and are sealed in special containers before going shipped to the storage areas.

This is only a short term method of storage. It is not suitable for long term disposal of nuclear wastes. Some utilities are starting to run out of temporary storage room for spent fuel in storage pools built near their reactors. Problems in nuclear waste disposal are not due to volume or weight of the material, however; the problem is ensuring that the wastes are isolated from human environment for from 600 to several thousand years.

There are several long term options under consideration for permanent disposal of nuclear waste. These include:

- o Rock salt formations deep underground
- o Other deep geological formations
- o Transportation out of earth's orbit
- o Burying under polar ice cap
- o Transmutation to non-radioactive or short half-lived substance.

Of these options, the mined geological repository seems to be the most promising. (Over \$300 million has recently been spent studying this option.)

A Presidential policy calls for burial in a deep earth depository by the mid 1990's, with the first site to be chosen by 1985.

The option of sea bed burial continues to be studied, however. The DOE has scheduled preliminary tests through 1987; but the feasibility of sea bed burial is not expected to be established, if at all, until well into the next century.

FIGURE 3-2: TAILORED VIGNETTE - NATIONAL SECURITY

FORECASTS	PROBABILITY/TIMING		
	1985-1990	1991-1997	1998-2005
OFFSHORE INSTALLATIONS IN SUPPORT OF NATIONAL DEFENSE OR SPACE NEEDS WILL INCREASE SIGNIFICANTLY IN NUMBERS:			
RANGE STRUCTURES	L	L	L/M
ACOUSTIC SURVEILLANCE	L	L/M	M
ICBM LAUNCH SITES	L	L	L/M
NUCLEAR WASTE DISPOSAL	L	L	L/M
THREAT TO U.S. OFFSHORE ASSETS WILL INCREASE SIGNIFICANTLY	M	M	H

H = High; M = Moderate; L = Low

CHAPTER 4: FOOD HARVESTING/PRODUCTION

The oceans have been a major source of food for all of recorded history. Indeed, with the exception of transportation, no use of the sea has been more important than food supply. Because the food web of the open ocean differs so dramatically from that of the land, however, man's development of ocean food resources has followed a much different course than his exploitation of onshore food resources. A combination of economics and availability resulted in fisheries remaining at the hunting and gathering stage of development thousands of years after the neolithic revolution changed man's relationship to land based ecosystems. Similarly, an abundant supply of arable land for onshore culture of food plants in the western world provided little incentive to exploit for human consumption the plant resources found in the ocean. A number of trends are bringing the neolithic revolution to the marine environment, telescoping into a few years steps that took hundreds of years on land.

The objective of any husbandry, whether plant or animal, is to convert relatively low-cost foodstuffs into high value, high quality protein or energy. Husbandry in the marine environment will not be an exception to that rule. Offshore structures associated with development of the ocean's harvesting/production of protein and energy may be classified by five functions related to the origin of the material and its end use:

- o Structures for animal husbandry
- o Structures for marine agriculture
- o Structures for culture of traditional onshore agricultural products in the marine environment
- o Structures for food processing
- o Structures for cultivation/processing biomass energy

The following are the types of harvesting/production systems with which this chapter is concerned:

<u>Source</u>	<u>Operational System</u>
Fisheries Management/Husbandry	Sea "ranches" Enclosed finfish/shellfish farms Offshore processing of animal food from the marine environment
Agricultural Development	Farming systems Offshore processing of plant food
Biomass Energy Conversion	Cultivation of biomass sources Processing systems for energy conversion

On first glance, it may appear inconsistent to include biomass as a fuel source in this chapter rather than in the chapter on energy. We have made this determination because the operational system for the conversion process is based on successful and economic marine agricultural systems. That is, while the end use is part of the mission category energy, its raw material production is dependent upon efficient agriculture. Moreover, as described below, the conversion process uses fermentation technology and will be common purpose with food processing.

BACKGROUND

Seafood, as an important element in man's diet, is showing no lessening in demand. In fact, most forecasters see human's using seafood as an even more important source of protein. A major component of the development of fishing as a marine industry has been innovations which were directed toward more effective capture and use of living ocean resources. Examples include improvements of fishing techniques advancing the state of the art from dependence upon a quick

hand and eye, to spears, to nets, and to using sonic instruments for spotting and attraction. Central to the modern evolution of this industry is the concept of fisheries management design to advance marine culture from a hunt and gather stage.

As currently used, the term "fisheries management" refers to management of the traditional hunt and gather fishing industry including control of living resources, as well as more experimental, less traditional techniques to develop plant and animal husbandry in the marine environment. The recent adoption of a 200 mile fisheries zone for American waters, coupled with restrictions on the size and type or catch within the zone, are examples of fisheries management techniques. Those techniques are designed to protect both the stocks of migrating fish and the domestic hunt and catch fishing industry from foreign competition. Development of a true husbandry culture for the marine environment is also seen increasingly as a part of fisheries management. While not yet as important in policy planning as improvement in traditional hunting of living food stocks, the extending of husbandry to the ocean is clearly an idea that will become more important as the end of the forecast period approaches. In large measure, how quickly the "neolithic revolution" comes to the marine environment will be dependent upon how successful more traditional techniques of fisheries management are in revitalizing that American ocean industry. Thus, while few--if any--offshore structures will be built to service the commercial hunt and catch fisheries, developments within that sector are very important to evolution of marine agriculture and animal husbandry.

An important variable in that generalization, however, concerns the development of ocean husbandry systems cultivating biomass for energy conversion. Given rather strongly enculturated Western food tastes, biomass is seen as

having the most potential commercial possibilities as an end use consumption system for marine plant resources. This is driven by interest in using kelp as a raw material for fermentation based production of fuels. Many analysts see kelp and other ocean plants as the best long term source of biomass raw materials for such conversion systems. We discuss in our forecasts the implications for marine food harvesting/production if such conversion systems prove feasible and are rapidly developed.

STAGES AND OFFSHORE STRUCTURES FOR FOOD HARVESTING/PRODUCTION

Animal Husbandry:

This emerging culture is composed of three functional systems:

- a. Management of resources for traditional hunting/gathering fisheries
- b. Sea "ranching"
- c. Sea "farming"

1. Cultivation

The components of this step change depending upon the functional systems, although they are similar for all three. In general, cultivation encompasses the "growing" of the animal resource. For traditional hunt and catch fishing, an introductory sub-section labeled "detection" is a part of the step.

Detection refers, in broad outline, to the "hunting" part of commercial fisheries. It is simply the techniques used to find the species for which the vessel is hunting. This is the component of the "cultivation" step which will generate the only offshore structures associated with the mission for commercial fisheries: the establishment of complex fish tracking monitoring stations are envisioned by some analysts to facilitate locating schools of an desired species.

An operational system of this stage for hunt and catch fisheries also include conventional restocking programs through state or federal hatchery organizations. Extensive offshore structures are not required for these programs.

In the case of sea ranching or farming, however, offshore structures are required for the cultivation stage. In the case of "ranches" such structure are likely to be floating pens of various sizes to hold small fish until they can be released to the open sea for maturation. Current and proposed layouts for "farms" (shellfish at present) "fence" off the mouth of a bay or other protected semienclosed body of water to protect the spawn from predators.

2. Harvesting

Unlike the "pens" and "fences" required for cultivation of fish resources in Step 1, this step needs no permanent or fixed facility. What is required is adaptation of conventional hunt and gather harvesting techniques such as trawling or seining. Much improvement is being made in the gear used to harvest fish.

3. Transportation

The in-between mode of transport from place of harvesting to point of processing. For the U.S. commercial fishing industry this step is usually accomplished by the same vessel that harvests the catch. Layouts for "ranches" and "farms" currently operational or in conceptual planning use conventional vessels to effect this step. Layouts for 2nd generation marine animal husbandry facilities envision a processing platform as a part of the installation (see appendix).

4. Processing

Currently this step is generally accomplished onshore, although some commercial hunt and catch fishing fleets are accompanied by a processing plant built into a "mother" ship. While there are a number of concepts that have been advanced for offshore processing facilities, we do not expect any to

be operational until after the forecast period of this report.

Marine Agriculture

1. Cultivation

This step may be part of two distinct operational systems. It may relate to cultivation of marine plants which occur naturally in the environment, or to artificial systems to culture that growth.

Offshore facilities for man-controlled culture of such marine plants as kelp are made up of a mesh installed below the water surface to act as a substrate for growth and pumps to create an artificial upwelling of nutrient rich bottom water.

2. Harvesting

Harvesting of marine plants is currently accomplished by reaper type barges. Future systems envision perfected versions of that type harvester.

3. Transportation

No offshore facilities will be needed for this stage. Harvested plants will be transported to the point of processing by the reaper vessel.

4. Processing

This step depends on the end use consumption system for which the product is designed. For that reason, this stage can vary considerably. Present systems of industrial seaweed processing use onshore production facilities. In the long term, it is anticipated that as kelp culture for conversion into fuels is developed, such processing facilities will be placed offshore.

Geographical Perspective

Even though different species of fish or marine plants have specific environmental requirements, such as water depth and temperature, that must be met for successful growth, a wide variety of potential "harvests" live in divergent environments and ecosystems. In this sense, marine animal and plant husbandry

as a general category of activities, can occur within virtually all American territorial waters.

TAILORED FORECASTS

In current literature, a great deal of attention is paid to the question of a world food shortage. At present it is still unclear whether current shortfalls represent the incapability of contemporary agricultural systems to supply the full amounts of food need on a global scale, or if the problem is primarily that distribution mechanisms are inadequate. Regardless of which view proves to be correct, potential food resources from the oceans will become increasingly important sources of protein.

End Use Consumption

Overall, seafoods and products are showing long term growth in demand. That growth is expected to continue. Current marine husbandry planning centers around these end uses:

- o Food sources
- o Fertilizers
- o Energy conversion
- o Minor end uses such as pharmaceuticals, sponges, fish/whale oil

In almost all of these applications, marine plant and animal resources compete directly with onshore materials that can serve the same end use. For that reason, the growth of marine husbandry (and the offshore structures associated with it) is dependent upon a number of nonocean variables. Such growth is also dependent upon variables related to the commercial hunt and catch fisheries.

There are a number of proposals for onshore agricultural productivity increases that could impact significantly on any forecasted demand for potential

marine husbandry products. These proposals include use of fermentation and biochemical processing to create high quality, low cost protein from lower quality onshore plant life. Another alternative source offering the potential for reducing demand for sea food products is projected productivity improvements in land-based agriculture. A substitute with similar potential for lowering demand for offshore husbandry products, however, is a similar product: onshore aquaculture of marine animal life in tanks or ponds.

Onshore cultivation and conversion of biomass for energy will also be an important variable in the development of marine agriculture, as will the more general consumer demand for fuels converted from biomass. At least some experimentation with biomass cultivation in the marine environment can be expected. The speed of development and demand, however, could be radically altered by the success of on-land sources of bioconversion in meeting needs, or the development of alternative energy sources. The use of biomass will be an important feature of land-based energy development alternatives.

Harvesting, Cultivation Systems

The first generation management techniques being applied to fisheries are almost all directed toward effective management and innovation for traditional hunt and catch fishing. Efforts that do fall under a concept of husbandry are a part of those techniques. Present planning for husbandry designed to help animal life thrive in its natural environment where it may be "hunted" include:

- o Efforts at predator and disease control among the most desirable species for human consumption
- o Hatchery design for selective restocking

Most management techniques continue to involve improvements in hunting or catching, however.

The continued improvement in traditional commercial fisheries is another important variable in development of a true marine husbandry culture. Great advances are being made in detection of the hunted species. Most fishing vessels are already equipped with some type of electronic detection system. The reliance upon and improvement of electronic or other detection systems will increase throughout the forecast period. New technologies that are emerging include:

- o The increasing sophistication of satellites' ability, utilizing laser and infrared technology, to spot moving fish
- o Underwater sensing systems that can accurately portray the location and size of fish using acoustic technology
- o Unmanned, passive systems placed on buoys to record, track and send the location of fish
- o Automatic computer vessel control systems coupled with onboard or radio-linked detection systems offer improved harvesting time as well as more efficient detection

The harvesting of marine animals is a function of the type of vessel and trapping system utilized. At present, the U.S. fishing fleet is at best aging and antiquated in comparison to the fleets of many foreign nations. Public policy is directed, as a part of the emerging fisheries management regime, toward encouraging the purchase of new equipment, the reconditioning of old vessels and innovation in harvesting techniques. Advances in harvesting techniques will include:

- o Expanding net size and adopting a funnel shape to "corral" fish in an enclosed area
- o Automatic, remotely controlled netting that is activated only when the desired catch is near
- o Development of unmanned submersibles to rapidly close netting

Commercial fisheries will also be able to use a number of systems that do not use nets for the entrapment of fish. Systems being developed include such techniques as:

- o Electronic stunning of the fish so that they float to the surface for gathering
- o Creation of a chemical "fence" through which fish can not move to keep them stationary for gathering (this technology has application for ranching or farming as well)

Transportation

Developing applications for interim transportation of marine food products include:

- o Taking the catch to processing while still in the harvesting net
- o Using adaptations of mining dredges attached to pipelines to gather the catch by vacuuming the bottom
- o Harvesting via unmanned submersibles which take the catch for processing

Processing Systems

For the purposes of this report, the only essential distinction between processing systems is whether they are located onshore or offshore. The only offshore processing systems in use currently are on-board processing represented by the floating factory concept. Onshore processing developments will, however, be important variables in the demand for ranched or farmed animal products. Presently, on-land systems are seeking to capture efficiencies. Technological improvements are being developed in the following areas:

- o Automatic shuckers for mollusks
- o Automatic deboners
- o Automated shrimp peelers
- o New product development

The question of new product development is perhaps the central variable impacting upon the speed with which marine animal husbandry needing new offshore structures will be implemented. There is presently, because of the relatively low quantity and rapid depletion of the more popular fish species, some questions

FIGURE 4-1: TAILORED FORECAST: FOOD HARVESTING/PRODUCTION

DIMENSIONS OF FORECASTS	MOTIVATING FACTORS	BARRIERS	OBVIATING FACTORS
Establishment of small number of kelp farms, with onshore fermentation into energy, food	DEPLETION of NON-renewable resources for energy	Highly capitalized	Substitute protein and food sources developed
Establishment of small number of kelp farms, with on-site structures for processing	By-products of fermentation include fertilizers, other needed products	High economic risk far from economic feasibility	Substitute energy re-sources developed
Traditional onshore food plants adopt and cultivated offshore	Demand for food	Regulatory structure uncertain	Alternative energy consuming systems adopted
Major developmental push, priority given for development of marine agriculture with on-site experimental processing in selected locations	Land farming involved in high competition for arable land	Use conflicts	Replacement of ocean sea animal resources by complete dependence on onshore resources
Zoned areas created for marine agriculture	Technical barriers seem of applied nature rather than demanding new breakthrough	Geophysical limitations	Substitute protein and food sources developed
True offshore "farms" combining plant and animal culture, harvesting and processing developed	Opportunity to increase overall productivity of one U.S. industry while creating energy	Alternative sources of energy and food may be less expensive to develop	
Animal Husbandry in marine environment is selected as the major	Demand for seafood		
	World "food problem"		
	Exhaustibility of fish stocks without restocking via "over fishing"		
	Opportunity to increase overall productivity of a U.S. industry		

Continued

FIGURE 4-1: TAILORED FORECAST: FOOD HARVESTING/PRODUCTION (CONTINUED)

DIMENSIONS OF FORECASTS	MOTIVATING FACTORS	BARRIERS	OBVIATING FACTORS
source for seafood production	Increase in absolute number of fish implies spin-off for commercial hunting industry and recreational fishing		
Consumer demand for animals seafood remains high			
Extensive, complex marine husbandry facilities built, including permanent structures for processing facilities			

whether the forecasted long term improvements in fisheries management for hunt and catch operations will be able to keep up with demand. Clearly, species substitutions will be necessary if commercial fisheries are to grow.

A variety of technological developments in seafood processing, including the use of fermentation and biochemical processing, will enhance analogs for expensive traditional seafoods such as shrimp and lobsters, while making possible blended fillets from "waste" fish or unpopular species that do not have a species identification but which do fit traditional tastes and textures. If such substitution is successful, the push will slow for development of mature marine animal husbandry systems.

Tailored Vignette

The ultimate direction of marine food production is from a hunting and gathering system toward a carefully managed culture of husband and harvest. In that movement, as is the case with so many of the marine missions discussed in this report, ocean systems are mirroring on land developments. In this case, it is the movement of onshore agriculture and animal husbandry from a hunting and gathering stage, through the neolithic revolution to our full scale battery of agricultural systems. The onshore evolution began thousands of years ago and still continues today. The agricultural revolution in the marine environment is in its infancy, but will be felt far quicker than its land-based counterpart; still, it will not be in operation until well after the turn of the 21st century.

1. Animal husbandry and the development of an agricultural culture within the marine environment will accelerate throughout the forecast period. Demand for protein from ocean animals will continue to increase, driving innovation in marine food production.

2. The concept of commercial fishing will be redefined to incorporate cultivation, harvesting, monitoring and management control which will be analagous

to onshore animal husbandry. Such concepts will be developed, however, within the context of the traditional commercial hunt and catch fisheries for onshore processing.

3. Substitute protein sources derived from the cultivation of marine plants will be developed within the duration of the forecast period, but will not replace enculturated consumer demand for traditional plant food or for conventional protein staples such as beef, poultry and fish. The prime demand for marine agricultural products will continue to be their current use in pharmaceuticals or as food additives, or as biomass for energy conversion or animal feeds. We expect, however, that for the forecast period onshore sources of biomass will remain both cheaper than marine sources and adequate to fill demand.

4. Unless one of the variables discussed in the general forecast section has significant impact, we therefore expect few agricultural offshore structures for food production or biomass conversion.

5. Demand for first generation marine agricultural products could be expanded if biochemical food processing can successfully convert marine plants into look alike, taste alike analogs for onshore food plants. Experimentation will be directed toward developing salt resistant species of on-land food crops that can be grown on an offshore substrate.

6. The contemporary U.S. hunt and catch fisheries will be revitalized and undergo revolutionary changes in the forecast period, slowing the maturation of a true system of marine animal husbandry. New processing techniques will allow the numbers of species captured as a food source to expand and include types of fish not now considered desirable. That trend will partially offset the depletion of current stocks by overfishing. More long-distance fishing in international waters will also become characteristic of the American fleet as such concepts as open stern trawlers/factory ships are utilized.

7. Those trends will slow full scale adoption of fish "farming" in U.S. waters by increasing supply. Experimental farms for species dangerously depleted can be expected in selected locations by the end of the period.

8. Animal husbandry will first be applied for restocking programs similar to those now taking place in fresh water lakes and streams.

9. The first offshore evolution of true animal husbandry will be in the form of limited "ranching" of migratory species. This first generation "ranching" of salmon, herring, or shad, will be harvested by the "hunt and catch" fleet, and so need no permanent offshore structures.

10. The utilization of offshore waters for a variety of activities, including experimental efforts at agriculture, ranching and farming, will create extreme use conflicts. These developments will lead specifically to zoned areas for agricultural production. Zoning will be essential to the successful establishment of a full scale marine agricultural system via integrated farming of plants and animals. That concept will, in turn, raise legal issues. By the end of the period, we can expect debate over the property of a private individual or a corporation enclosing "open" OCS space for a private profit making venture.

11. All of the developments thus far--the revitalization of the hunt and catch fishing industry, fisheries management, marine agricultural production for biomass, animal husbandry, and the creation of agricultural zones--will converge at the end of the forecast period to increase significantly the economic feasibility of integrated marine agricultural production. The contours of a true marine agricultural revolution, fully as important as the onshore neolithic revolution, will be visible.

12. As marine husbandry/agricultural activities increase, marine agriculture and animal husbandry studies will be instituted by educational institu-

tions to supply the highly trained personnel that will be needed.

13. All of the trends will combine to make feasible incremental investments in marine farms that in the 21st century will speed implementation of true offshore agriculture.

FIGURE 4-1: TAILORED VIGNETTE - FOOD & HARVESTING

FORECASTS	PROBABILITIES/TIMING		
	1985-1990	1991-1996	1997-2005
Animal husbandry in marine environment is selected as a major means of seafood production	L	L	L
Consumer demand for animal seafood remains high	H	H	H
Extensive, complex marine husbandry facilities built, including permanent structures for processing facilities	L	L	L
Small number of ranches for migratory species established in selected locations	L	M	H
Fish farms established for nonmigratory species	L	L	M
Farms established for shellfish and other expensive "luxury" marine animals	L	L	M
Zoned areas created for marine animal husbandry	L	M	H
At-sea agricultural production of kelp and other seaweeds increases because of U.S. consumers demonstrate willingness to substitute them for traditional plants	L	L	L
Consumer interest in traditional onshore plants remains strong	H	H	H
Establishment of small number of kelp farms, with onshore fermentation into energy, food	L	M	H
Establishment of small number of kelp farms with on-site structures for processing	L	L	M
Traditional onshore food plants adopted and cultivated offshore	L	L	L
Major developmental push, priority given for development of marine agriculture with on-site experimental processing in selected locations	L	M	H
Zoned areas created for marine agriculture	L	M	H
True offshore "farms" combining plant and animal culture, harvesting, and processing developed	L	L	L

H - High; M - Moderate; L - Low

CHAPTER 5: MINERALS

There is a general consensus that the next major "crisis" to be faced by the industrialized and industrializing nations also will be resource related and rival the "energy crisis" both in intensity and in long term implications; this crisis is likely to be a long range shortage of raw minerals and metals necessary for industrial societies to function. As in the case of energy, the world's oceans represent a rich potential source of mineral resources.

Within a broad technical framework the offshore mission category, labeled minerals, would include the extraction of all nonliving resources from the water, seabed, or beneath the seabed. For the purposes of our discussion, however, basic energy materials, such as oil and gas, which fit that definition are grouped under the mission energy and discussed in Chapter 2. This chapter deals with nonenergy related minerals which are extracted under the general rubric mining.

Offshore structures associated with development of mineral resources may be classified by four functions according to the origin of the mineral and the method used to extract it:

- o Extraction of mineral resources from the water, seabed or beneath the seabed in shallow waters
- o Extraction of mineral resources from the water, seabed or beneath the seabed in deepsea international waters
- o On site or near-site processing/conversion of minerals
- o Structural support for mining or processing of minerals

The following are the types of mineral mining systems with which this chapter is concerned:

<u>Source</u>	<u>Operational System</u>
Minerals present as unconsolidated deposits resting on, or comprising, the top few feet of the seabed, including sediments derived from adjacent land or precipitated chemically	Sand and gravel Limestone and shell Placer deposits Manganese nodules Heavy metals "Native" metals
Consolidated minerals which can be recovered by mining hard rock	Coal Sulfur Hard rock minerals
Minerals present as or which may be converted to liquids or gases	Salt Potash Minerals from icebergs

BACKGROUND

In many respects, particularly in processing technology, ocean mining has similarities to conventional onshore mining operations. The major difference is the nature of the mineral bearing body itself and, of course, the methods used to extract it. As is the case with the movement of the oil industry offshore, the extension of the mineral mining industry to the marine environment is a logical part of the general evolution of the mining industry and the result of a convergence of a number of long term trends.

Historically, an abundance of relatively inexpensive minerals was almost as important to industrialization and the development of modern societies as was the dependence on virtually unlimited, cheap energy. Current concern is centered around a complex of issues that question not only the long term supply of certain necessary minerals, but also their price and geographic distribution. In the minds of many analysts, the resolution of questions in all three areas is of vital importance to the short term and long term interests of U.S. national security. For that reason, any discussion of ocean mining finally hinges on practical matters of U.S. foreign policy as well as economic or technical factors "internal" to the industry.

The concept of turning to the sea for minerals is far from new. At least as early as the neolithic age, sea side cultures used beach sand and shells as building materials. This trend has continued, although land mining by far is the preferred form of extraction. Despite the vast potential of resource recovery in deep seas and near shore mining ventures, for most minerals it appears that on-shore exploitation will continue to be preferred well into the next century. This will be true except under the following conditions:

- o the minerals are of very high grade and easy access
- o the near-shore or offshore deposits located are made up of minerals which are in short supply, i.e., gold or platinum, or in tight supply because of expense, i.e., nickel
- o the near-shore or offshore deposits are extremely large and therefore can be recovered at a much faster rate than onshore mining

The three most important variables in the development and location of near-shore and deepsea mining are therefore demand, supply and environmental regulation. All three variables are very complicated.

For instance, there has been much debate over the need for manganese, cobalt, nickel, and copper, minerals which presently are economic to extract from nodules. Supply and demand of those minerals is not a simple question to untangle. Already the U.S. imports a significant percentage of these minerals, but moreover the international price stability of such minerals is highly unstable. Nine percent of the U.S. supply of cobalt presently is imported, primarily from Zaire, Finland, Belgium, and Norway. Canada supplies about 73% of the nickel consumed by American industries. Similarly, Brazil, Gabon and Zaire export 98% of the manganese use within the U.S. Even in the case of copper, where the U.S. now is the world's largest producer, the internal industry is dependent upon international prices, and there have been years

when foreign sources, primarily the U.S.S.R., Chile, Canada, and Zambia, have supplied around 10% of the total copper consumed domestically. The following table contains conservative estimates of U.S. dependence on foreign sources for minerals contained in nodules, with projections to the year 2000:

	<u>1950</u>	<u>1970</u>	<u>1985</u>	<u>2000</u>
Copper	31%	0%	34%	56%
Manganese	88%	95%	100%	100%
Nickel	94%	90%	89%	89%

Source: 1980 Industrial Outlook, Barkenbus, "International Conflict Over Resources."

Interacting with the nation's dependence on imports is the fear of OPEC-like supply cartels being formed for at least one of those minerals. That possibility is a highly debatable point. Economists and policy analysts have argued both sides of the issue vigorously; however, it does seem clear that the possibility for at least a short-term supply interruption for one or more of the minerals is a high probability for political, economic or military reasons.

International pricing policies already heavily influence even copper prices domestically. Between 1975 and 1978, U.S. production of copper declined and imports increased. This was because international prices were set below the published "producer prices" of U.S. firms. The producer prices, while historically influenced by international prices, always have been much more stable. In 1978, U.S. producers set their prices to the international markets, eliminating the price advantage imports had enjoyed. That action, coupled with the decline of the U.S. dollar against other trading currencies, resulted in a 60% decline in copper imports between 1978-1979,

with a concurrent 7% increase in domestic production. A long term factor, however, is that the relatively stable prices of U.S. copper will become increasingly susceptible to price fluctuations while larger demand and production of U.S. copper may use up our reserves even faster.

In addition to increasing domestic supply and reducing dependence on imports, it is felt that mineral recovery from the near-shore OCS or deep-sea could contribute significantly to the stabilization of prices in the world market. The price of cobalt, for example, has increased 136% since 1970, manganese by 16%. Even if economists do not feel such minerals are controlled by a cartel, the economy clearly could benefit by some price stabilization. Not the least important factor in this equation is the fact that all of the minerals which may be recovered by nodule mining are important to the strategic as well as economic interest of the U.S.

Demand for even the most basic and traditional minerals--sand, gravel and shell--extracted from near-shore areas, is expected to grow dramatically by the year 2000. While most of the increase could be satisfied by mining land-based deposits, coastal areas may be able to obtain aggregates more economically from near-shore mining. Similarly, it is expected that depletion of onshore resources of minerals such as gold and phosphite will push development of near-shore mining operations for those minerals.

A number of factors are converging so that the mineral potential of the oceans is being studied with intensity and investigated with massive capital investment. Important advances are being made in the technology of both near-shore and deepsea mining, including some fairly exotic equipment for near-shore or tidal areas to minimize environmental damage from dredging, such as hovercraft adapted to mining. Despite demand pressure and

technological improvement, however, two other related trends will mitigate against rapid development of coastal mineral reserves in the forecast period of this study, and push a more rapid development of deepsea mining systems. These are environmental concerns and legal/regulatory issues.

Environmental Impact, Use Conflict and Legal Issues

Coastal mining already is an important component of the American marine environment. The value of fresh water obtained from sea water is about 10 million dollars a year. Extraction of construction materials from off-shore sources constitute a 150 million dollar industry, while sand and gravel mining amounts to 70 million dollars and recovery adds another 40 million. While we feel that mining operations involved in extracting traditional minerals, as well as others such as phosphate and gold, will increase during the study period, they will not increase at the rate presently forecast by industry sources and will not be nearly as important as the mining of deep sea minerals.

Coastal mining has a very high potential for producing environmental effects. For instance, the two techniques most often used today (and of which new technologies are a variation) alter the shape of the bottom and interfere with marine ecosystems. Trailing suction hooper dredges, used for sand and gravel mining, cause a general bottom lowering of around five meters. Stational dredges leave a hole of up to 20 meters deep and 80 meters in diameter. In either case, there is a release of fine-grained solid materials from the bottom that may contain toxic material, or cover feeding grounds.

Dredging may change the shape of the bottom enough to alter local wave and current patterns. That alteration could lead to changes in shoreline erosion or disposition patterns, causing destruction of beaches, siltation of harbors, removal of offshore banks, or disruption of longshore and transport systems.

Experience has demonstrated that mining operations are hazardous to other marine operations and emplacements, causing collisions, disturbance of navigational buoys and cutting or displacing buried cables or pipelines. In addition, commercial fishing is disturbed by the creation of obstructions and the changing or migration or feeding grounds.

There are other potential secondary effects of coastal mining which occur mostly in the marine food chain. Physical changes include biological impacts caused by an alteration in the existing physical, chemical or trophic equilibrium. Such alteration may include variations in temperature, current patterns, amount and type of suspended particulates, light penetration and photosynthesis, and the creation of a new habitat. Those impacts are in addition to the primary effect on the food chain of involving certain species of plants or animals in the dredging operation and removing them completely.

When one couples the potential environmental effects of near-shore mining with the fact that of all the industries affected by government environmental regulations, few feel the impact more than the mining and processing of raw minerals, the overall economic competitiveness of OCS mining does not look optimistic. More than most other industries, the onland mining industry is subject to extensive and enforced regulations restricting land use, controlling discharge into water, land and air, and protecting employee health and safety. The federal government itself acknowledges that the cost of regulatory compliance has affected adversely the competitive position of this U.S. industry. The point is that there is no indication that the offshore mining industry will be any less regulated, and, in fact, there is evidence that it will be monitored even more strictly. It is hard to envision any regulatory system that does not subject the near-shore mining industry to the

same sort of environmental safeguards, including baseline environmental impact and monitoring, presently required of the offshore oil industry. This will be particularly true since the richest deposits of potential coastal resources listed in the appendix occurs close to shore, rather than fairly far out on the OCS.

Environmental regulation can be expected, therefore, to add greatly to the cost and time involved in exploiting coastal and near-shore mineral resources. In contrast, since the prime location for the rich, easily exploited deepsea resource likely to be mined in the first generation of ocean operations are well away from shore, and far from both commercial fishing areas and shipping lanes, few of the outlined environmental concerns apply to that industry. Furthermore, since nodule mining involves little bottom disturbance because the richest nodules are scooped from the sea floor, it is not as environmentally damaging as coastal mining. Development of deepsea mining hangs on another variable: the richest deposits are found in international waters and there currently is no legal system to allow for orderly, safe investment.

In response to that unsettled issue, recent U.S. legislation regulating U.S. firms engaged in nodule mining forbid any mining for profit until 1988. The entire law may be superseded if the Law of the Sea Conference is successful in negotiating a treaty for deepsea minerals.

The latest proposal, which many feel will be approved, provides for "parallel" development. Under this plan, a supernational seabed authority would be created. Private, or national firms, would bring claims for two mine sites to the authority. One would be exploited by and for the company, the other for the "common good of mankind" by the authority or as a joint

venture with another organization. The American bill protects U.S. interests by stipulating that on-sites claimed by U.S. firms' mining vessels, processing vessels, and at least one transport ship must be U.S. registered. On-land processing of the minerals must be in the U.S.

If both the legislation and treaty stand, the biggest barrier to commercial deepsea mining will be lowered.

STAGES AND OFFSHORE STRUCTURES IN MINERAL EXTRACTION

Mine site selection for near-shore or deepsea mineral extraction takes place in two stages--prospecting and exploration.

1. Prospecting

The goal of the prospecting stage is to reduce a wide area, which may contain extensive low-grade deposits, into a small area containing only the highest grade deposits. The process will be accomplished by a research ship that takes samples and conducts tests at different locations.

2. Exploration

The goal of the exploration stage is to obtain information for the final site selection. It consists of a detailed mapping of the most promising locations by a research ship.

3. Mining

The mining stage is the actual commercial recovery of the minerals. It is accomplished by the following structures and systems:

- mining platform
- power plant
- pipe handling system
- lift system

All of the systems may be combined onto one structure, like a mining ship similar in design and configuration of an oil and gas drill ship, or smaller vessels operating in tandem.

4. Transport

The transport stage is the method of transporting the minerals from the mine platform to the means of transport and then to the processing facility. The transport system

system varies widely depending upon the location of the mine site, the mineral being extracted, and the method of transfer. In some near-shore locations slurries are envisioned; in others, and for deepsea operations, transport ships will be used. In that eventuality, some sort of on-site storage facility is necessary.

5. Processing

For deepsea or near-shore mining in the first generation, which in terms of time will extend well past the period of this study, all processing functions will be performed on land. This stage, therefore, will generate the most on-shore impacts. Port facilities also would fall into this category.

GEOGRAPHICAL DISTRIBUTION

The appendix to this chapter (in Volume III) contains detailed listings of which minerals are likely to be located in U.S. near-shore areas.

Commercial quantities of nodules do not appear to exist in U.S. territorial waters.

TAILORED FORECASTS

End Use Consumption

It is difficult to see how world demand for minerals will decrease without a very real decline in present industrial intensity. Current and forecasted demand for mineral resources depends upon the interaction of all contemporary technological systems. Full exploitation of ocean resources will put off the inevitable debate about turning to or creating renewable materials for construction, industrial processing, precious metals, and fertilizers.

Offshore Mineral Reserve and Potential

While there is general agreement that the supply of ocean mineral reserves is finite, there are inadequate data and little agreement as to what that finite capacity will prove to be. The deposits thus far assayed

offer tremendous mining opportunities, but it is presently unknown if the reserves will prove comparable to on-land supplies of comparable minerals. If speculation that the ocean potential is at least equal to the amounts of minerals that have been extracted from the land environment, then the seas will supply minerals long after on-land reserves are depleted, assuming constant technological improvement.

Prospecting/Exploration

Detection systems for minerals have two main purposes--to locate deposits and to determine their grade. To date, mineral deposits have been prospected by sampling actual bottom deposits. Present experimentation is directed toward eliminating this expensive and time consuming step. Now in use or under development are a range of seismic, electric, magnetic and optical sensors to replace sampling. It is anticipated that future economies will be captured because scientists will be able to map and analyze mineral deposits accurately without the experimental extraction steps.

Mining

Most mineral extraction systems are defined by the technology used to bring the mineral out of the marine environment. Near-shore deposits are mined by dredging systems. At shallow depths, a conventional bucket ladder dredge is used which simply rotates a series of scoops from a surface vessel to the bottom and back again. As mining moves into deeper water, hydraulic pumps acting as large vacuum cleaners are utilized.

Among the technical concepts for improved mining are new corrosion-resistant materials, quicker rates of extraction, the ability to dredge through a variety of disruptive environments and withstand bending and shearing stresses. Some recent innovations include:

Shallow Water

1. Hovercraft dredges bring the ability to transport a dredge easily to its new location, especially in tidal areas, and to work shallow areas more cheaply.
2. Semisubmersible dredges provide greater stability and operate at greater depths than current systems.
3. Submersible dredges are remotely controlled dredges designed for sand and gravel operations in depths ranging from 20-100 feet.
4. Improved dredge head control will utilize such concepts as television monitoring of dredge head operation, underwater stabilizers, programmed control of operations in specific deposit pockets, and internal pumps to increase efficiency.

Deep Water

1. Hydraulic lift systems work like a huge vacuum cleaner to lift surface deposits such as nodules through a pipeline to the mining platform. This system has been tested successfully in depths over 2,000 feet.
2. Continuous bucket-line system is a string of buckets that lower and scoop nodules off the seafloor. This system has been tested in depths of 4,000 meters, but most experts feel that hydraulic lift systems will prove more dependable and more economical.

Transport

Two basic concepts exist for transportation of minerals from near-shore or deepsea mines. The present technology of slurry pipelines and a spin-off of land refill pipelines may be used. For example, phosphorite may be mined directly into a pipeline and delivered to a fertilizer plant. Such a pipeline would be flexible to accommodate the movement of the dredge head. The advantage of this approach is that it eliminates the need for transshipment vessels.

The second approach is the traditional one of using vessels for transport. This method also will be utilized. To improve the economics of transporting large quantities of mined resources, vessel size will increase to accommodate extraction efficiency. Within this perspective, the

FIGURE 5-1: TAILORED FORECAST: MINERALS

DIMENSIONS OF FORECASTS	MOTIVATING FACTORS	BARRIERS	OBTAINING FACTORS
High industrial economic growth is preferred choice of society	Expectation that ocean mining will provide opportunity for high growth industry	Comparative economic costs Environmental risks	Decline in industrial society
Mining of ocean mineral resources becomes important element in national policy	Demand for minerals greater than land-based supply	Conflicting uses Geophysical requirements	Substitute technological developments to fill present mineral demand
Cost disadvantages of offshore mining lessened by:	Need for greater national supply independence	Uncertainty of legal jurisdiction	Overriding loss of socio-political stability
Improved technology supply depletion supply cartels high cost for lower grade land-based supply	Advancing technologies to find and develop technological feasibility Recognition that present corporate capabilities and skills will be transferable	Uncertainty of technological capabilities Capital costs Regulatory uncertainty	
Substitute consuming systems will be developed to lessen demand for minerals			
Environmental issues will grow in importance			
Environmental issues will stop or reverse development of offshore mineral reserves			
Environmental issues will slow development of offshore mineral reserves			
Market conditions determine minerals extracted			
Hard rock mining for coal spreads to ocean			

development of a supertanker for mineral cargoes could be an emerging technology.

Processing Systems

Almost all minerals extracted from the ocean environment require some sort of further processing. For the purpose of this study the only important distinction is whether the processing facility is located offshore or onshore. In the case of onshore facilities the only impact of this study is on the nature of the transport system that provides the onshore/offshore hookup. Of course, many more implications are involved in the case of offshore processing facilities.

While plans for offshore mineral processing facilities are not yet at the development stage reached by offshore energy refining or conversion structures, there are concepts currently articulated to place fertilizer plants or nodules processing facilities, both of which are large consumers of energy, adjacent to or incorporated into offshore energy conversion systems. Moreover, some sort of mineral processing facility is usually envisioned as a part of any offshore industrial complex. Such concepts, however, will not be a matter of concern until toward the end of the present forecast period.

Tailored Vignette

Many of the fundamental issues associated with the overall development of offshore mining and mineral extraction are the same as those discussed in Chapter 2 of this volume on energy. This is particularly true of the choice of continued industrial intensity vs. the "pastoral" society. As we indicated in that chapter, we are confident that the choice will entail some type of continued industrial intensity. That choice will be played

out against a context of the need for much greater U.S. control over the stability of supply and price of society's major raw materials. Many of those minerals will be available only to the U.S. as a result of deepsea mining operations.

1. The general national need for development of offshore mineral reserves will emerge at an increasing rate and will be identified as an important national priority and policy imperative. Demand and need for all minerals will be far from uniform, however; the result will be an uneven development of components of an offshore mining industry rather than even development of all possible extraction activities. Since an important stimulus of that development is likely to be various forms of government incentives and regulations, the structure of any U.S. offshore mining industry will be shaped by government priorities.

2. Some consuming systems may find that suitable substitutes for various minerals are technically feasible. Despite this, end products for which the minerals are utilized, the reliance of sophisticated electronic systems upon them, and their use in new technologies will more than offset any loss of demand by the successful development of substitutes. The area most likely to see development of alternative systems is the phosphorite, limestone sector. This is because new genetic advances may lessen the reliance of the agricultural sector on chemical fertilizers.

3. Because minerals, like energy, are so fundamental to our sociocultural system, the social and political climate will be favorable to offshore exploitation of minerals. That favorable climate, however, will operate within fairly tight parameters. The context of social approval of ocean mining will be outlined by the continuing escalation in national importance of concern over the environment.

4. Environmental issues will remain a matter of national importance, but will not impede all areas of offshore mineral development. Concern will focus most stridently on the near-shore areas that are most fragile environmentally, and on those extraction techniques having the most potential for environmental damage. As environmental standards for offshore mining evolve, new extraction techniques at higher cost will develop. The costs of environmental regulation will not be uniform, however, throughout the offshore mining industry. These restrictions will be felt most severely by the near-shore industry extracting materials such as phosphates, shell, sand and gravel, and limestone. Such restrictions similarly will develop initially in those areas where conflicting uses will be most intense and where the most planning and regulation will be necessary. Dredging systems for coastal mining will have to be designed that do not disrupt the bottom contours and the ecosystem. Environmental restrictions will tend to push mining further away from shore and into deeper water, where environmental damage is less likely and use conflicts likely to be less severe.

5. Two contradictory sets of factors will be influencing the offshore mining industry as it develops. One set of factors will be operating to reduce the comparative cost disadvantages presently associated with development of offshore mines. These will include both those near-shore minerals like sand and gravel for which there already is an offshore industry and for which there will be growing demand coupled with on-land depletion of rich deposits, and minerals such as copper, nickel and manganese, which are considered to be central to national security and industrial development but of which the U.S. has a limited land-based supply.

Another set of factors will work to make some components of the offshore mining industry more cost competitive than others. These will include the

fact that environmental regulation will add more cost to near-shore operations than to deepsea operations, and the likely policy priority resting on the fact that the minerals which can be extracted more economically from deep-sea nodules are precisely the minerals for which the U.S. is most dependent upon foreign sources, and for which prices have been most unstable and most rapidly escalating. Thus, a combination of environmental concerns, supply-demand pull, and government policy, will further encourage faster development of deepsea mining than near-shore dredging. This conscious choice will heighten because the technologies for deepsea nodule recovery are nearly perfected, while environmentally safer techniques will need to be developed for near shore mining.

6. The issues rising from competing interests and conflicting uses of the ocean will combine with the other interests and conflicts discussed elsewhere in this report to require national policy guidelines for sea zoning and permissible uses of different areas.

7. Some form of management system for mineral resources seems likely to emerge within this decade. It appears possible that the suggested concept of "parallel development" will be adopted by the Law of the Sea Conference. While less than either the Third World or industrial world desires, it seems an effective short term solution. There will be significant pressure for the industrial nations which are resource dependent for rapid development of deep sea mining systems.

8. But, as the waters currently considered international are exploited, there will be pressure for nations to extend economic zones of influence well beyond the 200-mile limits to protect use of important sources of stability and wealth. That trend will create a number of conflicts over rights of access and transit, as well as charges by landlocked nations of

"injustice."

9. As a general offshore mining industry develops with discrete sub-industries, "spillover" effects will make economically feasible incremental investments in further exploration. Given the current rate of development, however, such a "takeoff point" in terms of the economies of development is not likely to be reached before the turn of the century. But, within the next two decades, the point should be reached where the contours of this emerging subeconomy and the points of proliferation will be discernible.

10. Our vignette for specific missions offers the following:

o Sand and Gravel

1. Demand for sand and gravel, because it is central to construction, will continue to accelerate. The cost of utilizing on-land deposits will increase. Already the mining of offshore sand and gravel is a stable, demonstrated technology, with at least limited application throughout the U.S. While the exploitation of land deposits of that material will become increasingly unattractive because of depletion of easily exploitable deposits and rising transportation costs, near term extensive expansion of near-shore operations is not probable. The existing technology for sand and gravel mining is coming under scrutiny for environmental damage and much stricter regulation can be anticipated, increasing cost. Offshore exploitation of sand and gravel should expand most near metropolitan areas where the increased cost can be offset by transportation savings.
2. As the demand increases, however, rapid technological adaptations and advancements will occur in mining techniques to meet and offset environmental restrictions. Economies in transport will be developed through such techniques as sending the dredged material directly to cement processing plants via pipeline.

o Limestone and Shell

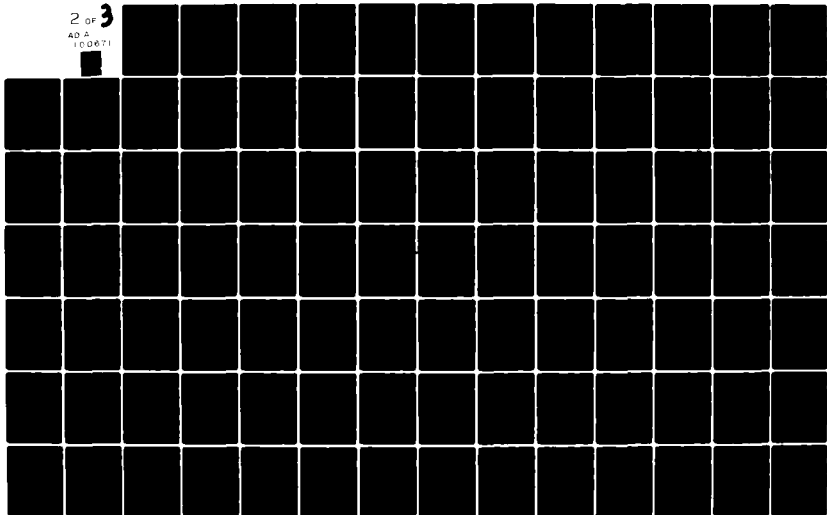
1. Mining of these materials is usually coupled with the extraction of sand and gravel. Much of the same pattern will inform both missions.
2. Since limestone is used as a base for some fertilizers, more expansion of mining for that mineral can be expected in the Gulf region where demand is highest. The development of

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alternative agricultural fertilizers discussed above, however, could cut demand rather dramatically.

Placers

1. Demand for the minerals lumped into the placer category will grow at a very high rate as on land supplies decrease and import prices rise. On the surface, since the metals in placers are critical to the national economy and are heavily utilized by industry, we should anticipate rapid development of placer mining.
2. We expect, however, development of this category to be slowed by a number of factors. The environmental restrictions on near shore dredging will impact heavily on placer mining, as will the cost differential involved in meeting regulations. As the near shore industry develops new technology there will be technological spinoffs enhancing the likelihood of placer mining. But, that development depends upon the increase in sand and gravel operations, which will also be slowed by environmental regulation. Similarly, placer mining, because of the stratified nature of the deposits, demands a more sophisticated dredgehead than is currently in use. Since many of the same minerals may be recovered by deepsea mining, and we are predicting faster development of that sector, placer mining will be retarded in comparison. It will take some time before the cost advantages and technological edge of deepsea mining make placer extraction economically feasible. That prediction, of course, is dependent upon the successful negotiation of a mineral extraction treaty at the present LOS negotiations.

o Manganese Nodules

1. The international competition for certain minerals, and the fact that the minerals found in nodules are largely imported by the U.S. will foster a very rapid development of commercial mining. Nodule mining has been demonstrated already to be technologically possible, and data indicate that it is close to being cost effective, if it is not now. The major barrier has been jurisdictional ambiguity, an issue that appears close to resolution by the concept of parallel development.
2. Technological advances in mining will facilitate the rate and depth of extraction, further enhancing the cost effectiveness. Initial mining will take place in the Pacific since key mineral density is greater there than in other locations.
3. Because environmental issues and use conflicts do not appear important for the first generation of nodule mining, and because the technical capability is in hand, deepsea nodule mining will develop at a far faster rate than near

shore mining for placers, sand and gravel, and limestone and shell. While demand and technological improvements will gradually neutralize the cost advantage nodule mining will have over other types of ocean mineral extraction, that event will take place at the end or beyond the forecast period of this study.

o Phosphorite

1. The large land based supply of this and related minerals will deter extraction until the end of the forecast period.

o Metaliferous Muds/Red Clay/Ooze, and Other Rare Earths

1. Since the on-land supply of these materials are adequate at present, and very high mining costs are projected, we do not expect to see any sizeable commercial activity in mining for the forecast period.
2. It is possible that by the year 2000 technologies developed for oil and gas recovery and nodule mining may have a spinoff application for these minerals. The most likely region for such extraction would be the Red Sea, which is rich in metaliferous muds. We do not expect any activity beyond the experimental.

o Chemical Extraction

1. The demand for fresh water will continue to increase, which will result in new innovations to produce water. So desalination plants will expand in size and number. Since the U.S. has comparatively lesser need than arid countries, we expect little utilization within U.S. waters. Adaptation of such techniques within the U.S. will most likely occur in regions that are arid or subject to drought. Southern California is the most likely candidate.
2. Activities extracting salt, bromine and magnesium from the ocean will also continue, but these processes will continue to take place on-land, and so will not involve offshore structures.

Figure 5-2: TAILORED VIGNETTE - MINERALS

FORECASTS	PROBABILITY/TIMING		
	1985-1990	1991-1997	1998-2005
NEAR-SHORE INSTALLATIONS FOR MINING OF HIGH-NEED MINERALS WILL BE IN PLACE IN SIGNIFICANT NUMBERS	L	L	M
ACCELERATION IN PLANNING CONSTRUCTION OF OFFSHORE INSTALLATIONS FOR MINERAL MINING WILL TAKE PLACE	L	M	H
THE NEED FOR OFFSHORE MINERALS WILL BECOME STRONGLY FELT IN THE U.S.	L	M	H
SOCIAL AND POLITICAL FACTORS WILL COUNTER-BALANCE ENVIRONMENTAL FACTORS IN THE OFFSHORE MINERAL MINING ISSUE	L	L	M
WORLD MARKET PRICES OF MINERALS WILL INCREASE LEADING TOWARD INCREASING THE ECONOMIC FEASIBILITY OF OFFSHORE MINERAL MINING	L	L	M
THE U.S. WILL EVOLVE A MANAGEMENT SYSTEM FOR OFFSHORE MINERALS TAKING INTO ACCOUNT FEDERAL, STATE, AND FOREIGN FACTORS	L	M	H
INTERNATIONAL CONFLICT WILL BE CLEARLY VISIBLE OVER RIGHTS TO MINERALS IN THE OFFSHORE REGIONS OUTSIDE THREE-TO-TWELVE MILES	L	M	H
DEEP SEA NODULE MINING WILL ADVANCE AT A RATE CONSIDERABLY FASTER THAN ANY OTHER MINERAL MINING; IT WILL CONTINUE TO BE AN INTERNATIONAL ISSUE OF RIGHTS	M	H	H
THE U.S. WILL ENGAGE IN DEEP SEA NODULE MINING ON A COMMERCIAL BASIS	M	H	H

CHAPTER 11: GROWTH MODEL

The purpose of this chapter is to provide a general description of the process by which an offshore installation (OSI) evolves from an idea in the mind of an individual to a fully operating industrial installation.

CONTEXT

Our observation during this study and its predecessors has been that one of the major impediments to efficient growth of the U.S.'s capability to extract offshore resources has been administrative/political. Interminable time seems to be taken up during the decision making process to identify every possible objection by every possible political body. If any party objects for whatever reason, our pluralistic system grants that party the right to hold up the decision, no matter how serious the need to get on with the operation. This theme emerges repeatedly, both here and in Chapter 12 following.

This chapter provides foundational material for the rest of the study in the following respects:

- o A common framework from which to describe the state of growth of any OSI, and to identify obstacles in this growth process;
- o A guide for assessing the state of growth of some future OSI;
- o A means of identifying the points of contact between an emerging OSI and its offshore and onshore environments--physical, economic, social, political, technological;
- o A check list to assess Coast Guard possible points of interaction with the emerging OSI universe--leading to assessment of both implications to the Coast Guard and options open to the Coast Guard.

We have added a section at the end of the chapter comparing the OSI growth processes in the U.S. with the U.K. The latter is much less time consuming, probably because of somewhat lower allegiance to pluralistic values. Even in

the U.K., however, it is clear that the process could be shortened considerably, should there be resolute direction in response to a quantum jump in priority.

We emphasize that the model in this chapter is highly generic; the precise process through which OSI growth occurs in reality depends upon demographic, economic, political, ecological, and technological factors.

The process depicted in this chapter is essentially an adversary one, with at least two and often more protagonists; the government is always one and industry is almost always the other. Invariably, other interest groups are also involved. Almost no offshore installation can be approved without at least one party perceiving itself as a "loser". That fact is at the heart of explaining why the process is so slow. Issues are frequently economic or environmental, but may also be social or political.

THE GROWTH PROCESS

Figure 11-1 depicts the general stages of growth for an offshore installation. Probably no OSI followed this sequence exactly, but every OSI's growth can be approximately described in terms of each of the elements of Figure 11-1. A general description of the growth sequence follows.

Planning:

Figure 11-2 depicts the parallel flow of government and industry in the growth process.

OCS OSI development planning at most of the phases outlined in Figure 11-2 is highly uncertain for both industry and the different levels of government. Indeed, uncertainty may be the word best suited to describe the entire process for all the actors. Industry, for example, cannot be certain if a given tract of the OCS will provide a large enough oil or gas find to make production economical. Capital investment is unlikely in other possible OSI (i.e., deepwater

ports or floating power plants) because of long lead time, shifting government priorities, or meeting local needs.

FIGURE 11-1: GROWTH MODEL--OFFSHORE INSTALLATIONS

1. Need/opportunity perceived:

Within federal agency, regional agency, state agency, local body, private corporation, other institutions, private citizen.

- o Development/refinement of need/opportunity through idea interaction and through publication in media, professional journals, trade journals, books, legislative hearings, research reports, etc.
- o Research and preliminary development. Continuing dissemination of ideas.
- o Development of an interest group.
- o Formalized research and development; technological feasibility established.
- o Preliminary engineering studies; prototype development; testing; engineering evaluation.
- o Studies to match opportunity to need; alternative actions considered.
- o Possible future environments of applications identified.
- o Economic and political feasibility assessed; sociological feasibility assessed; environmental impact assessed.

2. Alternative studied.

Purposeful consideration by potential decision makers of different ways to match the opportunities with the needs identified in 1. above.

- o Alternatives reduced to manageable number of options.
- o Geographical/physical exploitation and associated conclusions.
- o Economic/political/technological criteria of suitability and desirability established.
- o Means of measuring options against criteria developed.
- o Measurement of alternatives against criteria conducted.

(Continued)

FIGURE 11-1: GROWTH MODEL--OFFSHORE INSTALLATIONS (cont'd)

3. Selection of alternative most likely to meet criterion of optimality.

Tentative decision by key decision makers to proceed with one of the alternatives under consideration; subject to change as events unfold, but firm enough to make investment of time and funding.

- o Administrative action started at federal, regional, state and local levels.
- o Financial interest group identified.
- o Financing action commenced.
- o Coordinative network among interest groups established.
- o Interest group network focused into decision to proceed.

4. Administrative processing.

Initiation and processing of all leasing, licensing, and other papers required at all levels of government before an offshore structure may be commenced.

- o Paper filing begun.
- o Governmental reviews begin; initiator-government interaction.
- o Litigation/coordination/controversy takes place.
- o Approval granted with specified conditions.
- o Conditions met sufficiently to begin; administrative processing continues throughout all steps.

5. Physical operations begun in marine environment.

Movement of construction resources into the marine environment at the site at which the OSI is to be erected, and actual beginning construction.

- o Exploratory structures placed; operations commenced.
- o Sites for permanent structures established.
- o Design criteria established.
- o Structure plans--architectural and engineering--completed and disseminated.
- o Construction contracts let.
- o Construction team and equipment organized.

Continued

FIGURE 11-1: GROWTH MODEL--OFFSHORE INSTALLATIONS (cont'd)

- o Operating base for construction set up.
- o Prefab work commenced.
- o In-place construction operation commenced.

6. Construction support system established.

Building the necessary facilities and logistics support activities to enable the construction to proceed.

- o Further contracting for down-stream construction.
- o Logistics support by competitive contracting.
- o Administrative support established for construction process.
- o Full-scale construction support system established.

7. Logistics support system construction begun.

Establishing the necessary facilities and logistics support systems to enable the OSI system to operate after it has been completed and placed into its operating mode.

- o Requirements studies completed.
- o Design specifications completed.
- o Contracts let
- o Construction begun.

8. Construction completed.

OSI sufficiently complete to permit initial operation in its designed mode.

- o Testing of components.
- o Testing of full units.
- o Acceptance of units.
- o Full test operations begun.
- o Sign-off of construction contracts.

(Continued)

FIGURE 11-1: GROWTH MODEL--OFFSHORE INSTALLATIONS (cont'd)

9. Operations begun.

Beginning of operation of OSI in fulfillment of its designed function.

- o Test operations completed.
- o Bugs ironed out.
- o Logistics support system geared up for full scale operation.
- o Functional operations begins.

10. Steady-state operations established.

Having completed a shakedown period, OSI settles into the operating mode that it is likely to maintain for most of its useful life.

- o Technical transients settled out.
- o Economic transients settled out.
- o Political transients settled out.
- o Social transients settled out.
- o Steady-state operations achieved.

11. Termination begun.

Usefulness of structure approaches its end; rate of usage begins to slow.

- o Operational slow-down.
- o Employment of output declines.
- o Onshore interdependence begins decline.

12. Termination.

Final closing down of the operation.

- o Structure becomes inoperative.
- o All employment and interaction with economy ceases.

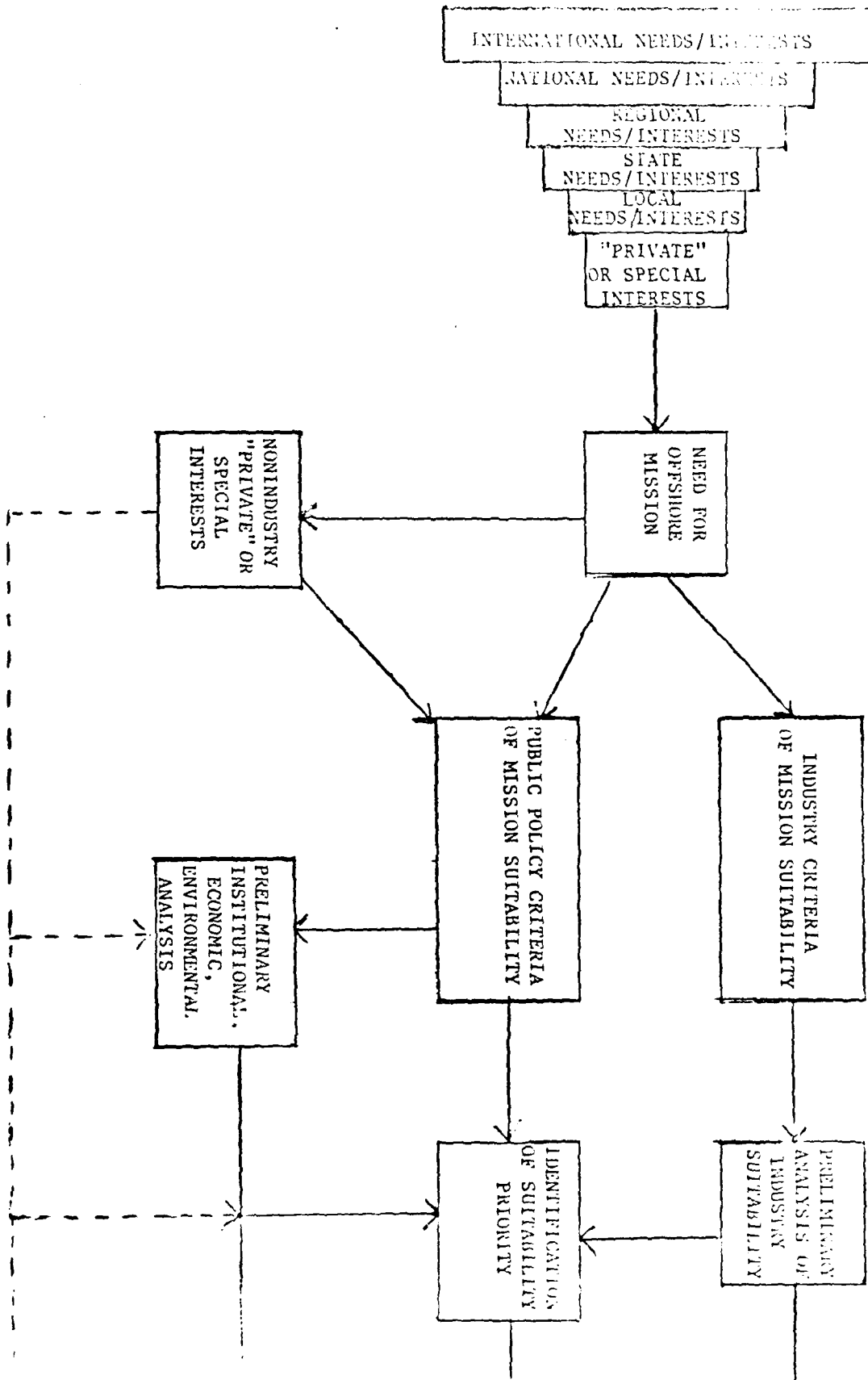
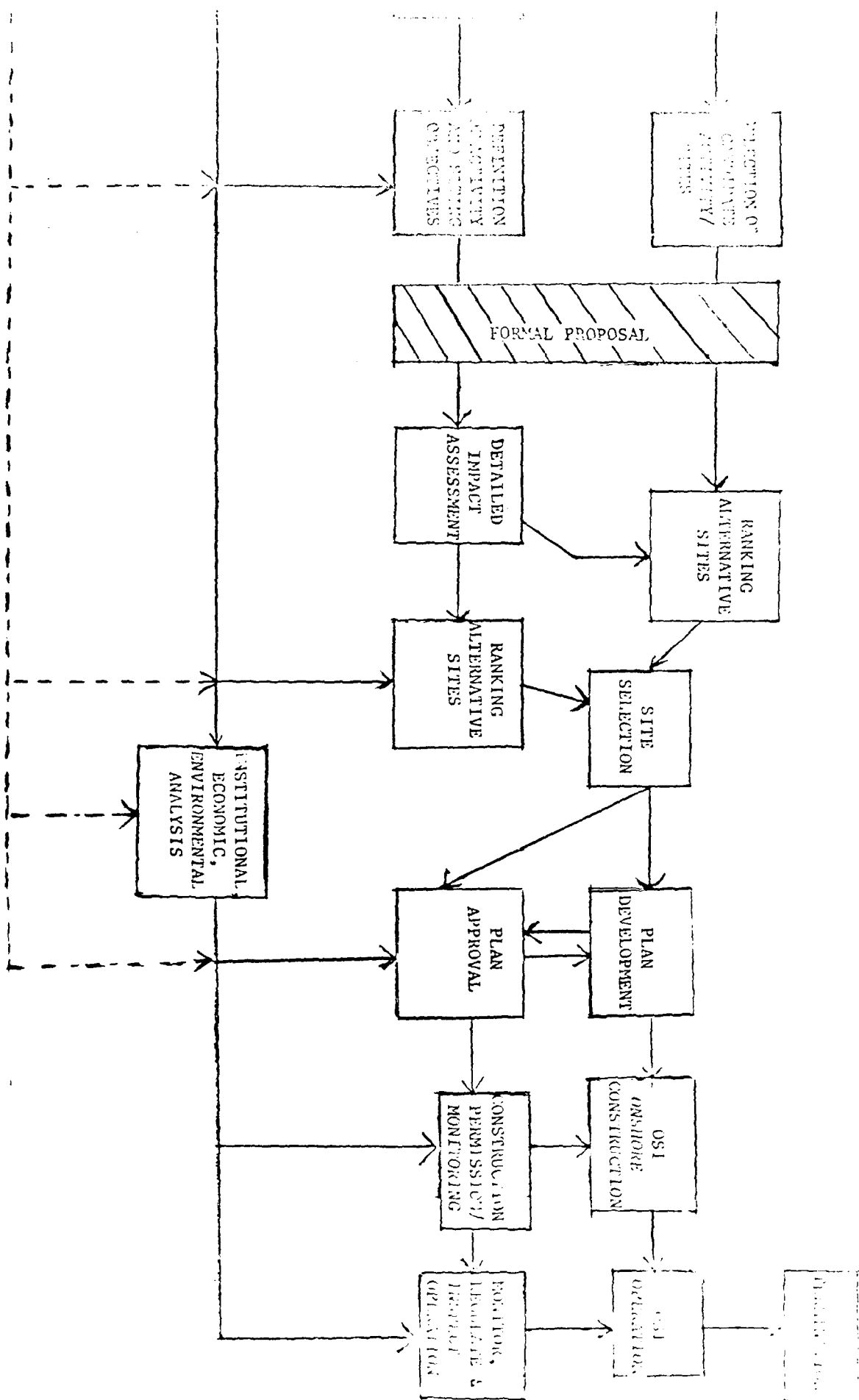


FIGURE 11-2: GROWTH MODEL: PLANNING PROCESS FLOW DIAGRAM

STATISTICAL PHYSICS



Conversely, public policy planners are forced to make decisions based on incomplete data about environmental or socioeconomic impacts which may only be estimated or which are not completely understood. The results of key public policy decisions are often highly uncertain.

Within the flow of OSI development, with its long lead time, high degree of uncertainty, and the very significant, often irreversible impacts, there appear to be two discrete areas of planning. Each is driven largely by external forces and events, and each involves different priorities for planners representing divergent interests. The point of division is represented in Figure 11-2 by the hatched box marked "Formal Proposal".

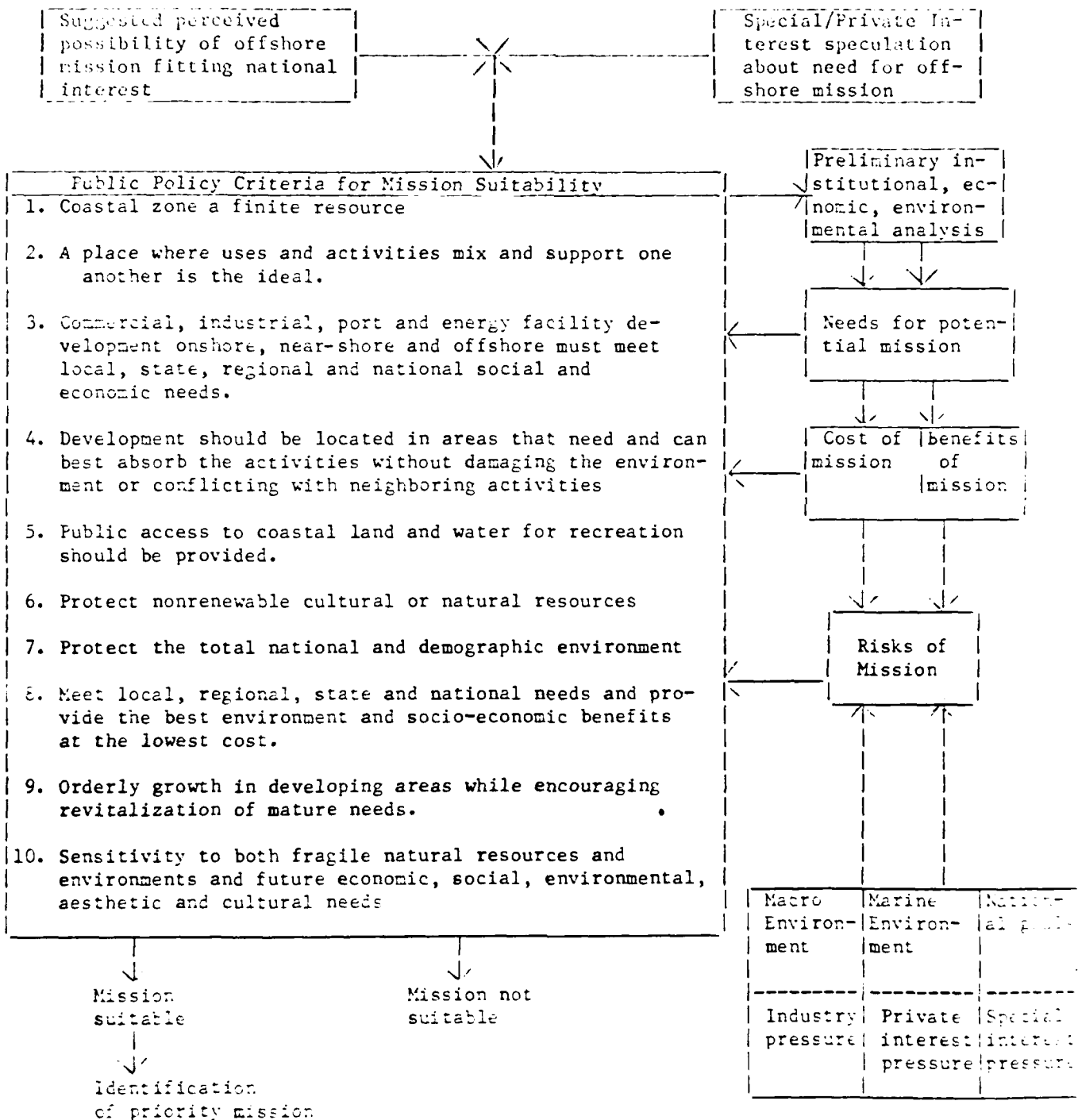
Before a formal proposal is generated--whether it is a government-initiated announced leasing schedule or an industry-initiated announcement to develop a OSI--each phase, while expensive for the actors, is theoretical. Once actual intent is established the "game" becomes real with massive social, political and economic consequences.

Public Policy Phase:

Figure 11-3 summarizes the public policy criteria against which the OSI mission, activity, siting and project suitability are measured, and which help determine a mission's priorities. The criteria remain the same no matter which level of government or public interest is applying them. The answers, however, may change. This is so because risk, cost and benefit of the mission may vary from the national, regional, state or local levels.

Costs, benefits and risks between individuals and locations are different because of wealth transfer effects as well as actual impacts on the state, region, locality or individual. A trade-off that may seem acceptable, indeed even necessary to meet a national need, may be unacceptable or appear not worth the cost to the area most heavily impacted. Examples of wealth transfer includes:

FIGURE 11-3: PLANNING PROCESS FOR DESIGN: PUBLIC POLICY REQUIREMENTS
OSI DEVELOPMENT: MISSION SUITABILITY PHASE



- o A federal program currently makes the hulls of old liberty ships available to individual states. These hulls are outright grants so that the state may sink them in order to establish artificial fishing reefs. The federal government's gift of liberty ships to the states is clearly a benefit from the standpoint of each state. When one looks at the gift from the point of view of the taxpayers of noncoastal states the gift is a cost since these individuals are giving up to the federal government the potential revenue of the salvage of the hulls.
- o Similarly, the gift represents a benefit to a charter boat operator in an affected state (say Alabama) because his business should increase because of the fish attracted to the new reef. In contrast, the hulls which are a benefit in Alabama may impose a cost to charter operations in Florida because they will lose some business to Alabama as a result of the new reef.
- o A OSI sited in an area with high unemployment would create real benefits to that locality. The same structure could impose a high cost on another area, however, by attracting skilled or needed labor to the new development, creating a labor shortage.
- o Even fulfillment of a clear national goal with huge national benefits like OCS oil development may place large costs on local areas which outweigh any local benefits. Each stage of development places strains on the local infrastructure. Many communities find it difficult to expand such facilities, especially if the population growth or employment increase is temporary. This is particularly true since local tax revenues always lag behind the local/state investments which accompany OSI development. Similarly, OCS taxes presently go to the federal government, not to the states or localities. Such revenues come down to those units through loans or other federal grants and thus reflect national rather than regional priorities.
- o The job market for local residents need not necessarily keep pace with development. Because of the specialized labor needed for oil and gas technology and other capital intensive OSI now envisioned, local employment may even deteriorate. That is particularly so if the proposed OSI would or could adversely affect the area's traditional economy: farm land could be pre-empted; commercial fishing impaired, recreational activities decline, or labor might be priced out of traditional jobs by the competition of higher OSI wages.

The set of priority missions which result from the end of the mission suitability phase may show a large variance depending upon what level of public agency evaluates public policy criteria of mission suitability.

Figures 11-4 and 11-5 depict the detail of the rest of the public policy planning process. Central to each sub-phase within the model are increasingly detailed

forecasts, and assessments and analysis of environmental, social, economic and political impacts of development. Analysis is first directed toward determining what the objectives of specific OSI activity and siting should be. Once a formal proposal is made including a detailed industry management/development plan, the impact studies become very specific. Table 1 provides a general framework for public policy impact assessment.

Public policy planning for each OSI phase moves from general national goals to the specific activity, applying increasingly detailed assessments. So too, do industry planning phases.

Industry Planning Phases

As depicted in Figure 11-2, industry development phases run parallel to public policy ones and duplicate or overlap with them in several instances. Industry criteria, however, tend to be far more specific than public policy criteria, and far less complex, although far from simple.

Figures 11-6 through 11-9 contain details of each industry phase and are straight forward and relatively self-explanatory. Before any other criteria can be applied, individual firms must first determine if the proposed mission and environmentally practical activities are within company capability. Largely this determination is ruled by external factors such as onshore requirements, and by government incentives/disincentives.

Probably one of the few potential benefits from the long lead time involved in OSI development is that it provides the time necessary for states and firms to make changes in regulatory procedures to guarantee that develop-

FIGURE 11-4: PLANNING PROCESS FLOW DIAGRAM: PUBLIC POLICY REQUIREMENTS: DEFINITION OF ACTIVITY AND SITING OBJECTIVE PHASES

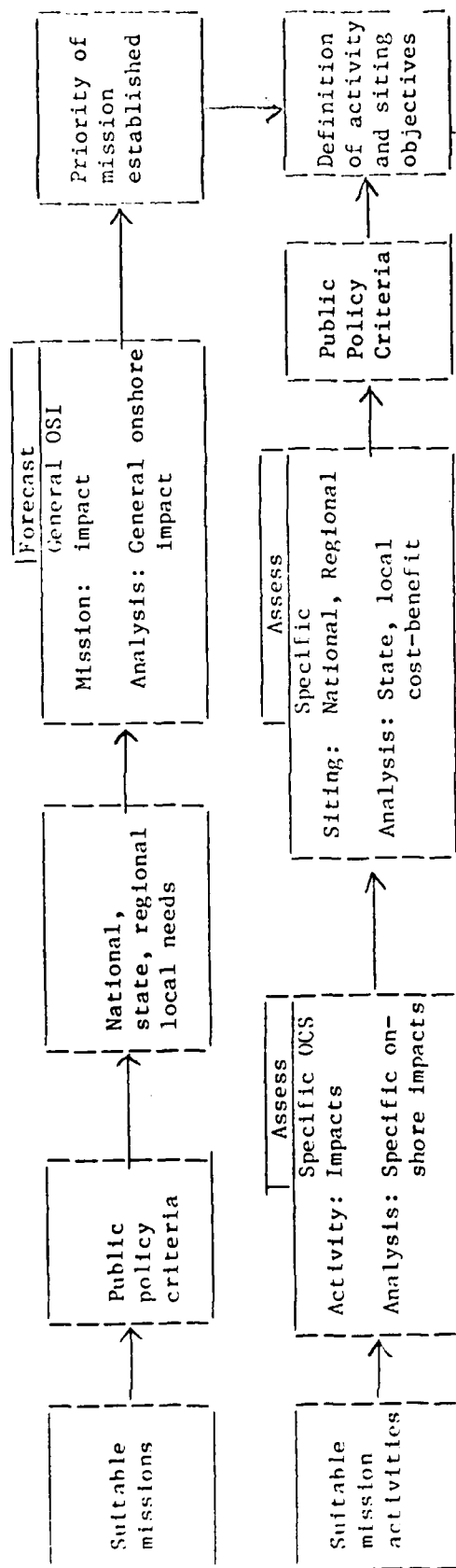


FIGURE 11-5: PUBLIC POLICY REQUIREMENTS: PLAN APPROVAL; PROJECT MONITORING PHASES

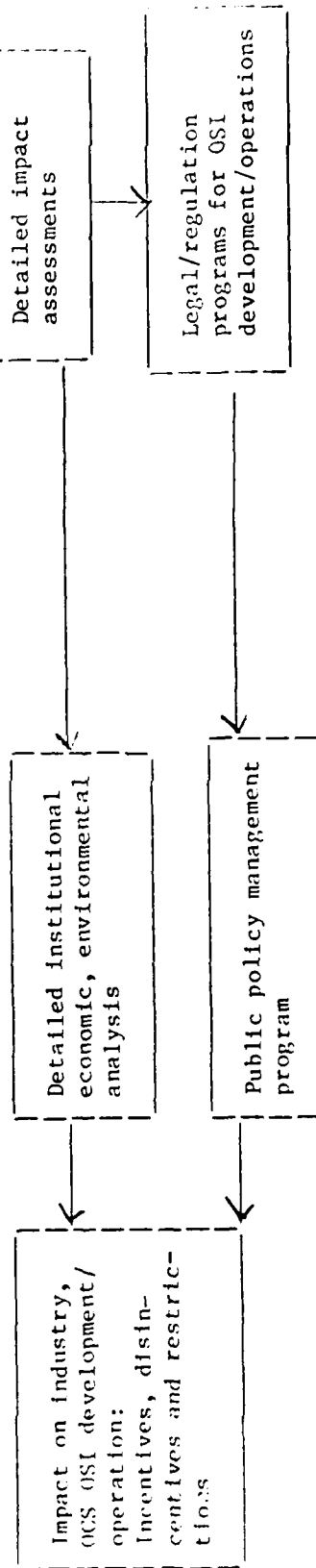


TABLE 1: FRAMEWORK FOR EIS

Specific Steps

Step 1

Analyze proposed industry work plan

Formally review and analyze management's plan permit applications to learn the exact nature of the planned mission, activity and stages of work

- Identify projects with their relevant design features
 - Identify subprojects and their construction methods and operating characteristics
-

Step 2

Select projects and subprojects with potential for significant impacts

- Screen identified activities for potential disturbance to ecology, habitats, socioeconomic systems
 - Select for study those with potential for significant disturbance
-

Step 3

Analyze potential disturbance for specific levels of impact

- Description and sources of disturbance
 - Description and sources of adverse effects from disturbance
 - Description of disturbance-effect sequence and likely impact of each disturbance
 - Description of probable additive/cumulative effects and likely impacts of each disturbance
 - Description of probable beneficial effects and impacts
-

Continued

TABLE 1: (Continued)

Step 4

Identify mitigation techniques for work plan

- Design/layout changes
- Construction or operation changes
- Mitigation opportunities by enhancement or restoration
- Substitute projects/subprojects

Step 5

After analysis of Steps 3 and 4 accept or reject work plan, or grant conditional acceptance

Step 6

Make final recommendations

ment goals are attainable. From the point of view of the flow of industry planning, however, that fact also means that ultimately regulations--not company or even government policies--determine the patterns and forms of development. This is clearly depicted in Figures 11-2, 4, and 5-8. Public policy regulations have far more impact upon industry than does industry on regulations. That fact is particularly acute in the site selection phase and operational development phase outlined in Figure 11-9.

The problems of planning for regulatory impact are exacerbated because not only is the process linear, but each phase had depth as well. The levels begin at the national, and work down to regional, state, local and ultimately, individual. Each provides its own planning and regulatory functions which interact with each separate block Figure 11-9. The result is that industry planning phases are almost unbelievably uncomplicated. See also Tables 2 and 3.

FIGURE 11-6: PLANNING PROCESS FLOW DIAGRAM: INDUSTRY REQUIREMENTS OSI DEVELOPMENT--INDUSTRY CRITERIA OF MISSION SUITABILITY PHASE

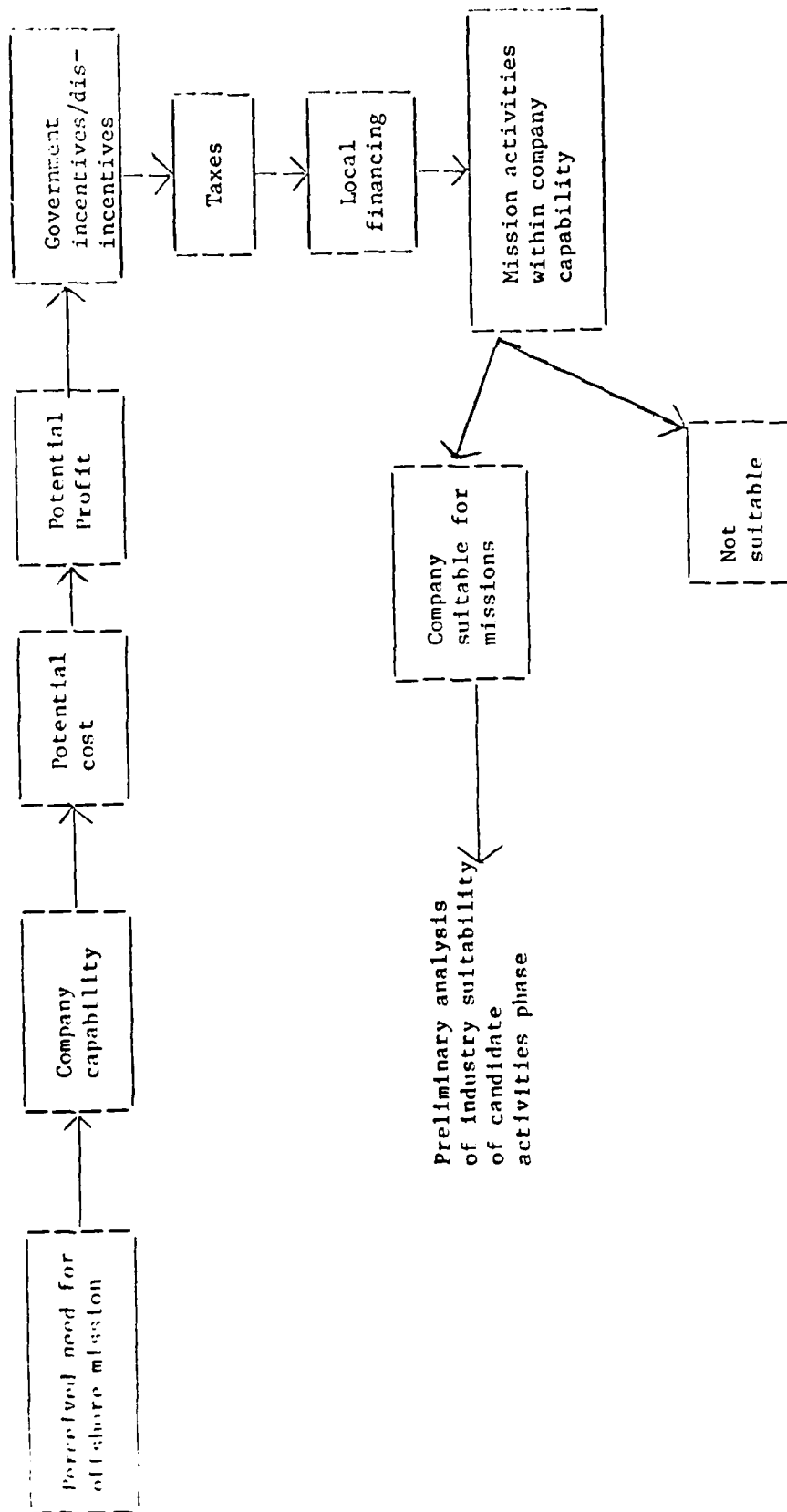


FIGURE 11-7: PLANNING PROCESSING FLOW DIAGRAM: INDUSTRY REQUIREMENTS OSI DEVELOPMENT--PRELIMINARY ANALYSIS OF INDUSTRY SUITABILITY FOR CANDIDATE ACTIVITIES PHASE

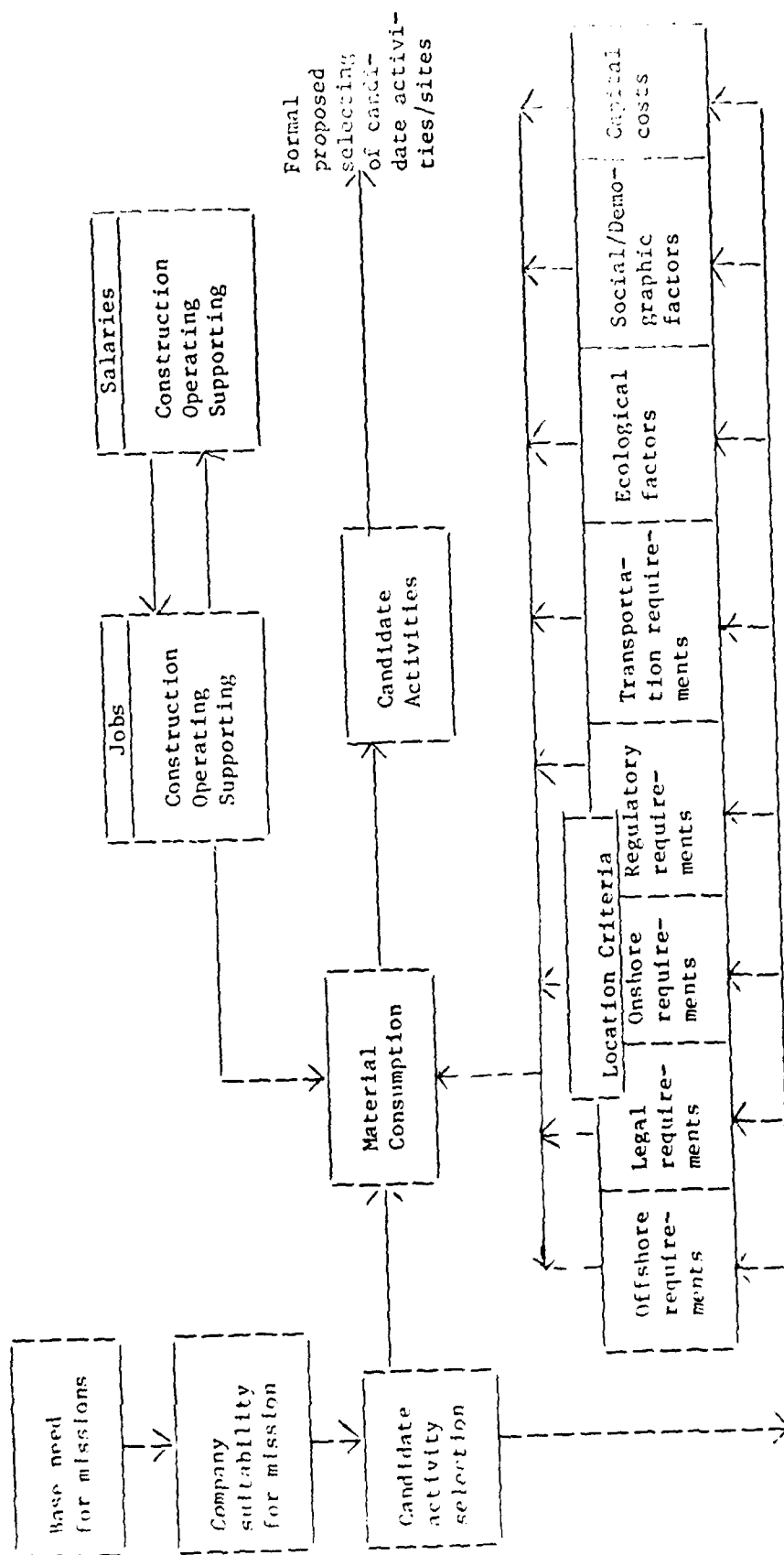


FIGURE 11-8: PLANNING PROCESS FLOW DIAGRAM: INDUSTRY REQUIREMENTS OSI DEVELOPMENT--SELECTION OF CANDIDATE ACTIVITY/SITE PHASE, RANKING ACTIVITIES/SITES PHASE.

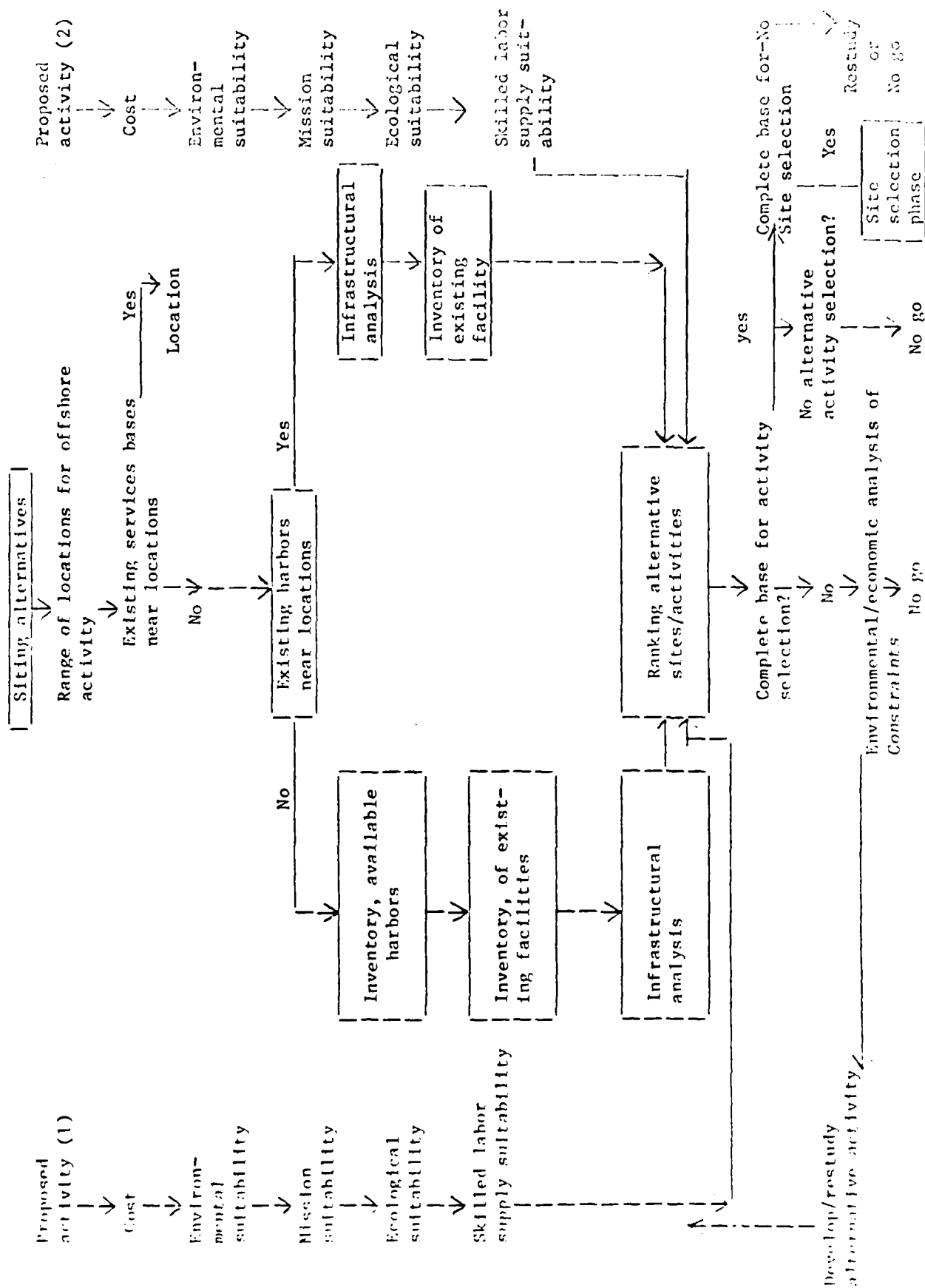
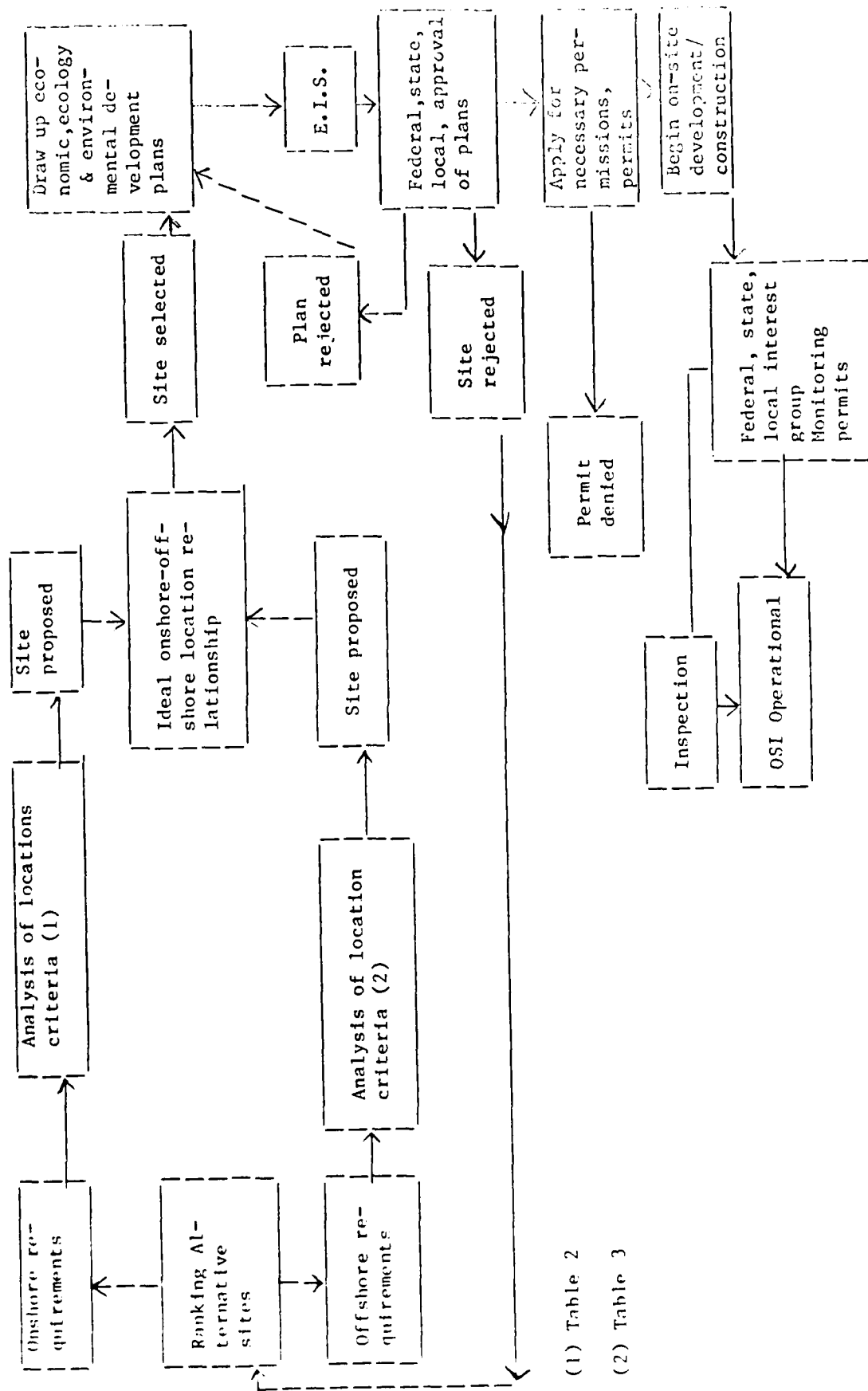


FIGURE 11-9: PLANNING PROCESS FLOW DIAGRAM: INDUSTRY REQUIREMENTS OSI DEVELOPMENT--SITE SELECTION PHASE/
DEVELOPMENT PHASE.



(1) Table 2

(2) Table 3

As shown in the Government model, the federal regulatory framework alone is frighteningly complex. About 40 federal agencies, ranging from NOAA through The Federal Trade Commission to the Advisory Council on Historic Preservation have some sort of oversight responsibility at one of the phases of the growth model.

Figures 11-10 and 11-11 illustrate the response of merely one federal agency to two rather small points of the growth model's phases. Figure 11-10 shows the internal steps taken by the Fish and Wildlife Service to activate projects and subprojects which may require federal permits. It would take place in the selection of candidate activity/site phase (Figure 11-8). Figure 11-11 is that same agency's responsibilities once a formal permit application is filed with COE. It becomes staggering when one considers that for the same permit such internal flows are necessary in at least six other agencies. Similarly, each phase and step within the growth model requires the same sort of effort with all reviewing, commenting, monitoring or approving agencies.

Moving down to the state level, one sees the same kind of overlap. Figure 11-12 is a matrix depicting state agencies in Massachusetts and South Carolina having permitting or planning/management authority over OSI development. As is the case at the federal level, each state agency has an internal review procedure. Projects or subprojects for onshore support of OSI which typically require state as well as federal permits include the following:

- o Zoning use designation
- o Permission to subdivide land
- o Certification of flood proofing and location outside highest flood hazard areas
- o Wetlands conservation or impact mitigation
- o Site alteration assurance to guard against erosion or drainage alteration

- o Dredge and fill permit
- o State environmental codes

Of course, if the OSI were sited less than 3 miles from the state's shore the installation itself would fall under state regulatory authority.

Figure 11-13 depicts an actual case of state-federal regulatory approval interaction between agencies. The example is for an LNG plant in California. So far, plant development has been in various planning phases for 12 years. Approval for actual program formulation has still not been granted. This example is rather simple because the listed agencies deal only with the plant's OCS siting. Others will become involved as onshore support location criteria are applied. See Figure 11-14 for a general depiction of the shoreline permit procedure.

Local permitting, zoning, or approval functions add another dimension to each phase of the growth model. There are probably more variations among restrictions of different county or municipal authorities than at any other point in the model. This is so because local regulations, as well as strictness about granting approval, are very dependent upon local attitudes toward development. That fact also makes local regulations more volatile than at either the state or federal level.

That is, while there are differences in regulations from state to state, and the regulatory framework of some states is more complex than others, in general, state CZM plans share common features. For example, all state CZM plans have some regulations and procedures governing development of wetland and tidal areas. Virginia is far more tolerant of the kinds and amount of wetland development, however, than is California. Similarly, compare Massachusetts and South Carolina in Figure 11-12:

- o 14 state agencies in Massachusetts have responsibility for missions falling under the category of mineral extraction or energy production

- o 3 South Carolina departments or agencies have authority for missions falling under energy production, 3 for those in the category of mineral extraction

In contrast, local zoning may be much different in communities which are very close to each other. And the sort of welcome a developer receives may range from warm to glacial between towns which are actually contiguous. The point is that local permitting authorities are far more sensitive to narrow interests and constituencies than are state or federal authorities.

Regardless, all state CZM plans call for specific local approval or approval for OCS development in addition to the routine zoning and permitting requirements for onshore construction.

Figure 11-13 portrays the typical local/state procedure.

GROWTH MODEL: TABLE 2

INDUSTRY LOCATION CRITERIA FOR OFFSHORE/ON-LAND SUPPORT FACILITIES

- o Labor force required and turnover, likely stability and average cost
- o Relationship to markets, location of partial processing facilities and interindustry transfers
- o Local financing
- o Taxes
- o Utilities
- o Transportation
- o Housing, education and other social factors
- o Facility land requirement, land availability and its characteristics
- o Area preference, e.g, metro area, non metropolitan area, industrial park, isolation, etc.
- o Environmental controls, standards
- o Compatibility of industry and community goals and objectives
- o Regulation for land use
- o Foreign investment policy
- o Capital requirements
- o Emissions, effluents, other impacts
 - air
 - waste water
 - noise
 - solid wastes
 - aesthetic
 - sedimentation/run off

GROWTH MODEL: TABLE 3

INDUSTRY LOCATION CRITERIA FOR OFFSHORE SITING

- o Relationship to exploitable resource
- o Relationship to marketing, location of partial processing facilities and interindustry transfers
- o Relationship to onshore support harbors/facilities
- o Water depth
- o Slope stability
- o Underwater slides
- o Foundation quality and properties
- o Sand invasion
- o Bottom currents
- o Surface currents
- o Weather patterns
- o Wave pumping
- o Safety
- o Use plan compatability
- o Vessel traffic patterns
- o Site acquisitions
- o Acceptable level of risk of accident
- o Potential shoreline alterations
- o Legal/regulatory framework of environmental controls, standards, sea use
- o Energy, water requirements

GROWTH MODEL: TABLE 3 (cont'd)

INDUSTRY LOCATION CRITERIA FOR OFFSHORE SITING

- o Transportation
- o Emissions, effuents
- o Aethetic
- o Taxes
- o Compatability of industry & community goals
and objectives

FIGURE 11-10: ILLUSTRATION OF FISH AND WILDLIFE SERVICE RESPONSE TO CONSTRUCTION ACTIVITIES APPARENTLY REQUIRING U.S. ARMY CORPS OF ENGINEERS PERMITS

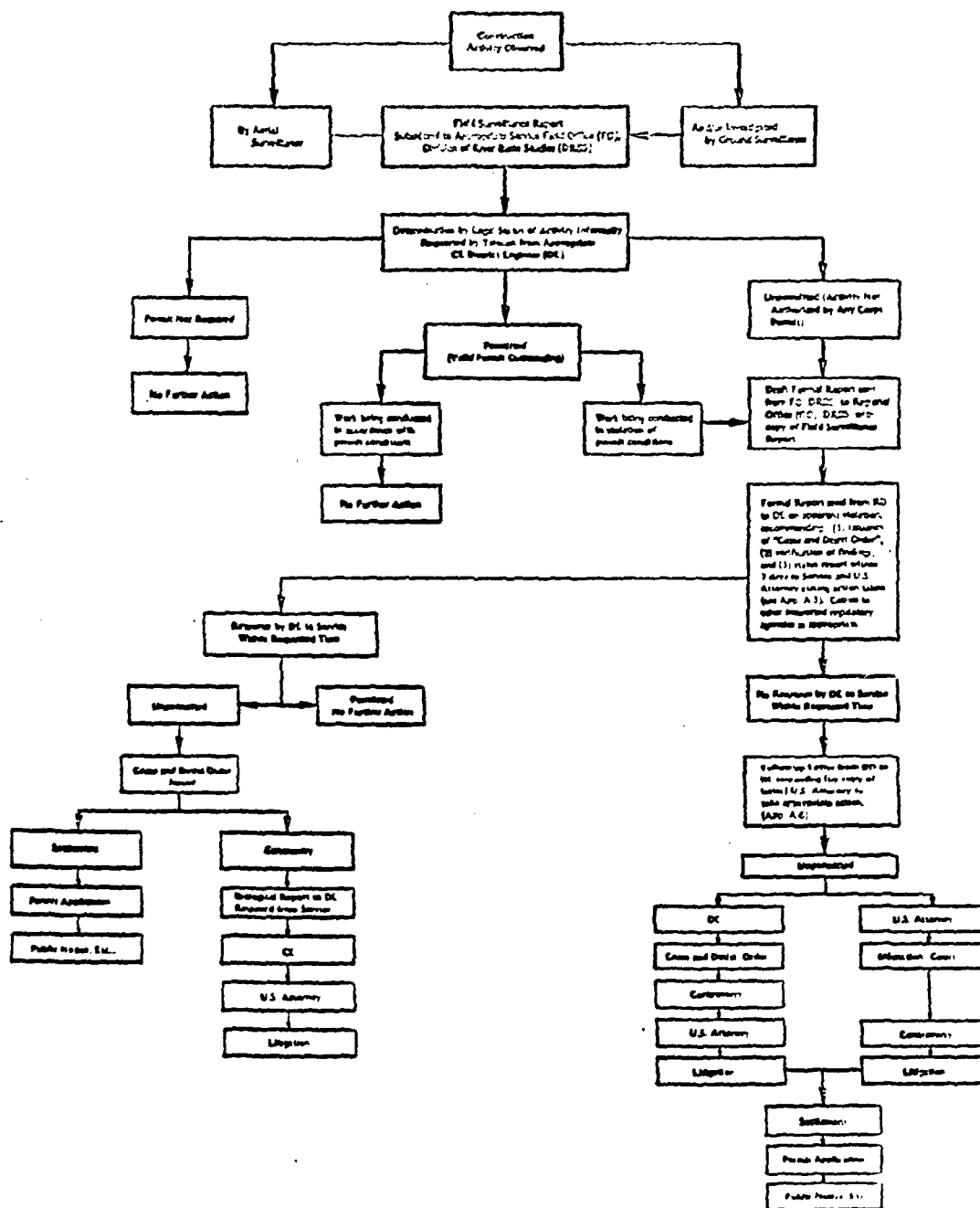
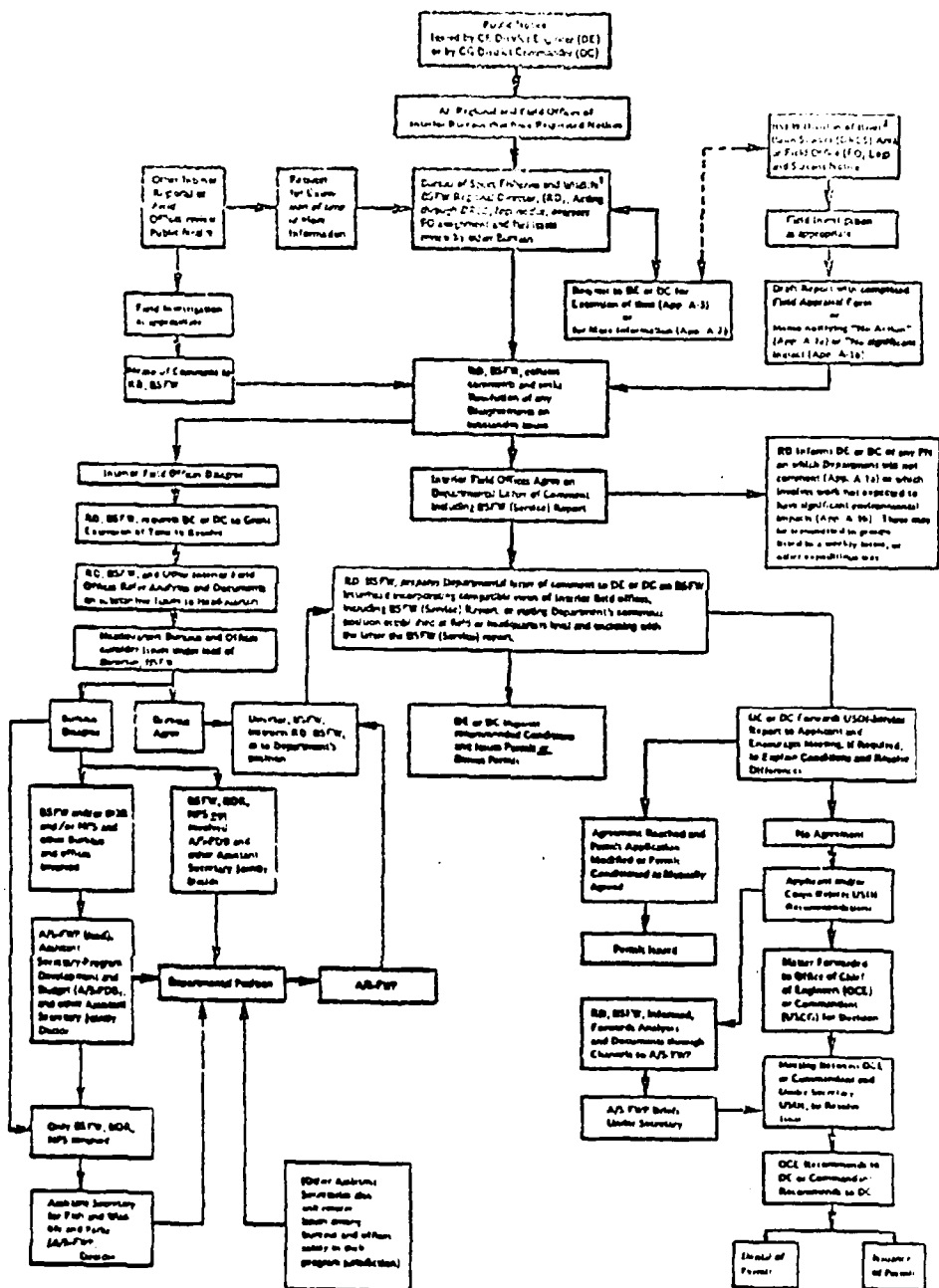


FIGURE 11-11: ILLUSTRATION OF FISH AND WILDLIFE SERVICE PARTICIPATION
IN THE U.S. ARMY CORPS OF ENGINEERS FISH AND WILDLIFE REVIEW PROCEDURES



¹U.S. Fish and Wildlife Service
²Division of Ecological Services

State: MASSACHUSETTS
FIGURE 11-12

ACTIVITY	AGENCY											
	Federal	Local-Regional	Office of Environmental Affairs	Office of State Planning	Energy Policy Off.	Energy Facility Siting Council	Conservation Services	Div. of Environmental Impact Rev.	Div. of Law Enforcement	Div. of Environmental Quality Imp.	Land & Water Use	Div. of Outdoor Advertising
residential development	x	x	x	x				x	x		x	
ports	x	x	x	x	x		x	x			x	x
roads, highway	x	x	x	x			x	x				x
airports	x	x	x	x								
parking facilities		x	x	x				x				
railroads	x	x	x	x				x				
agriculture	x		x	x					x		x	
forestry			x	x			x		x		x	
mineral extraction	x	x	x	x	x	x	x	x	x	x	x	
manufacturing			x	x			x	x	x	x	x	
energy production	x		x	x	x	x	x	x	x	x	x	
fish and seafood process			x				x	x	x		x	
aquaculture			x	x			x	x	x			
commercial incentives	x		x	x								
parks	x	x	x				x		x			x
tourist attractions	x	x	x	x								x
cultural resources	x	x	x				x	x	x			x
marinas		x	x	x				x	x			x
boat ramps		x	x	x				x				x
docks and piers		x	x	x				x			x	x
dredge material disposal	x		x				x	x	x		x	
salvage			x				x	x	x		x	
underwater salvage			x				x	x	x		x	
artificial reefs			x					x	x			
impoundments			x						x		x	
sewage treatment	x	x	x	x				x	x	x	x	
solid waste disposal	x	x	x	x				x	x	x	x	
buildings		x	x	x	x	x		x				
dams and reservoirs	x							x			x	
water supply	x	x	x	x				x			x	
erosion control	x	x	x	x			x	x	x	x	x	
air quality	x	x	x	x	x		x	x		x	x	
water quality	x	x	x	x	x		x	x		x	x	
wildlife									x			
pipeline	x		x		x	x			x			
marine construction			x	x	x	x	x	x	x	x		

Agencies with permitting or planning/management authority.

STATE: MASSACHUSETTS

FIGURE 11-12

ACTIVITY	AGENCY *											
	Air & Hazardous Materials	Water Pollution Control	Mineral Resources	Environment Management	Water Resources	Fisheries, Wild-life & Recreation	MDC	Food & Agriculture	Martha's Vineyard Commission	Dept. of Transportation	Housing	History & Culture
residential development	x	x							x		x	
ports	x	x							x	x		
roads, highway									x	x		
airports									x	x		
parking facilities									x			
railroads										x		
agriculture								x	x			
forestry				x		x		x	x			
mineral extraction	x	x	x			x			x			
manufacturing	x	x				x			x			
energy production	x	x		x		x			x			
fish and seafood process	x	x				x		x	x			
aquaculture						x		x	x			
commercial incentives												
parks				x					x			x
tourist attractions				x					x			x
cultural resources				x					x			x
marinas									x			
boat ramps									x			
docks and piers									x			
dredge material disposal		x		x	x				x			
salvage									x			
underwater salvage									x			
artificial reefs						x			x			
impoundments									x			
sewage treatment		x		x	x		x		x			
solid waste disposal		x		x	x		x		x			
buildings							x		x			
dams and reservoirs					x		x					
water supply		x			x		x		x			
erosion control				x	x		x		x			
air quality	x											
water quality		x			x		x		x			
wildlife						x						

Agencies with permitting or planning/management authority.

STATE: SOUTH CAROLINA

FIGURE 11-12

AGENCY *

ACTIVITY	Federal	Local	Coastal Council	Aeronautics Comm.	Archaeology & Anthropology	Budget & Control	DHEC	Development	Forestry Comm.	Highway Dept.	Land Resources	PRT
residential development	x	x	x			x	x					
ports	x		x			x						
roads, highway	x	x	x			x		x		x		
airports	x	x		x		x		x				
parking facilities		x	x			x	x					
railroads	x	x	x			x		x				
agriculture	x		x								x	
forestry			x						x			
mineral extraction	x		x			x						
manufacturing		x	x				x					
energy production	x	x	x			x	x	x				
fish and seafood process			x				x					
aquaculture			x			x	x					
commercial incentives	x	x	x			x	x					
parks	x	x	x					x				x
tourist attractions	x	x	x				x					x
cultural resources	x	x	x				x					
marinas		x	x			x						x
boat ramps		x	x			x						x
docks and piers			x			x					x	
dredge material disposal	x		x									
salvage												
underwater salvage			x		x							
artificial reefs			x			x						
impoundments			x									
sewage treatment	x	x	x			x	x					
solid waste disposal		x	x				x					
buildings	x	x	x				x					x
dams and reservoirs	x											
water supply	x	x	x			x						
erosion control	x	x								x		
air quality	x	x	x				x					
water quality	x	x	x				x					
wildlife & fisheries			x									

(Continued)

* Agencies with permitting or planning/management authority.

STATE: SOUTH CAROLINA

FIGURE 11-12

AGENCY *

ACTIVITY	Patroit's Point	Railway's Comm.	PCA	PSC	Housing, Authority	SPA	Water Resources	Wildlife/Marine											
residential development					x	x													
ports																			
roads, highway						x													
airports																			
parking facilities																			
railroads						x													
agriculture																			
forestry																			
mineral extraction																			
manufacturing																			
energy production			x	x		x	x												
fish and seafood process																			
aquaculture								x											
commercial incentives																			
parks	x																		
tourist attractions	x																		
cultural resources	x																		
marinas	x					x													
boat ramps								x											
docks and piers						x													
dredge material disposal																			
salvage																			
underwater salvage																			
artificial reefs								x											
impoundments							x	x											
sewage treatment																			
solid waste disposal																			
buildings																			
dams and reservoirs			x																
water supply			x																

FIGURE 11-13: EXAMPLE OF JURISDICTIONAL AUTHORITY & REGULATORY APPROVAL REQUIREMENT (CALIFORNIA) FOR OFFSHORE INSTALLATIONS

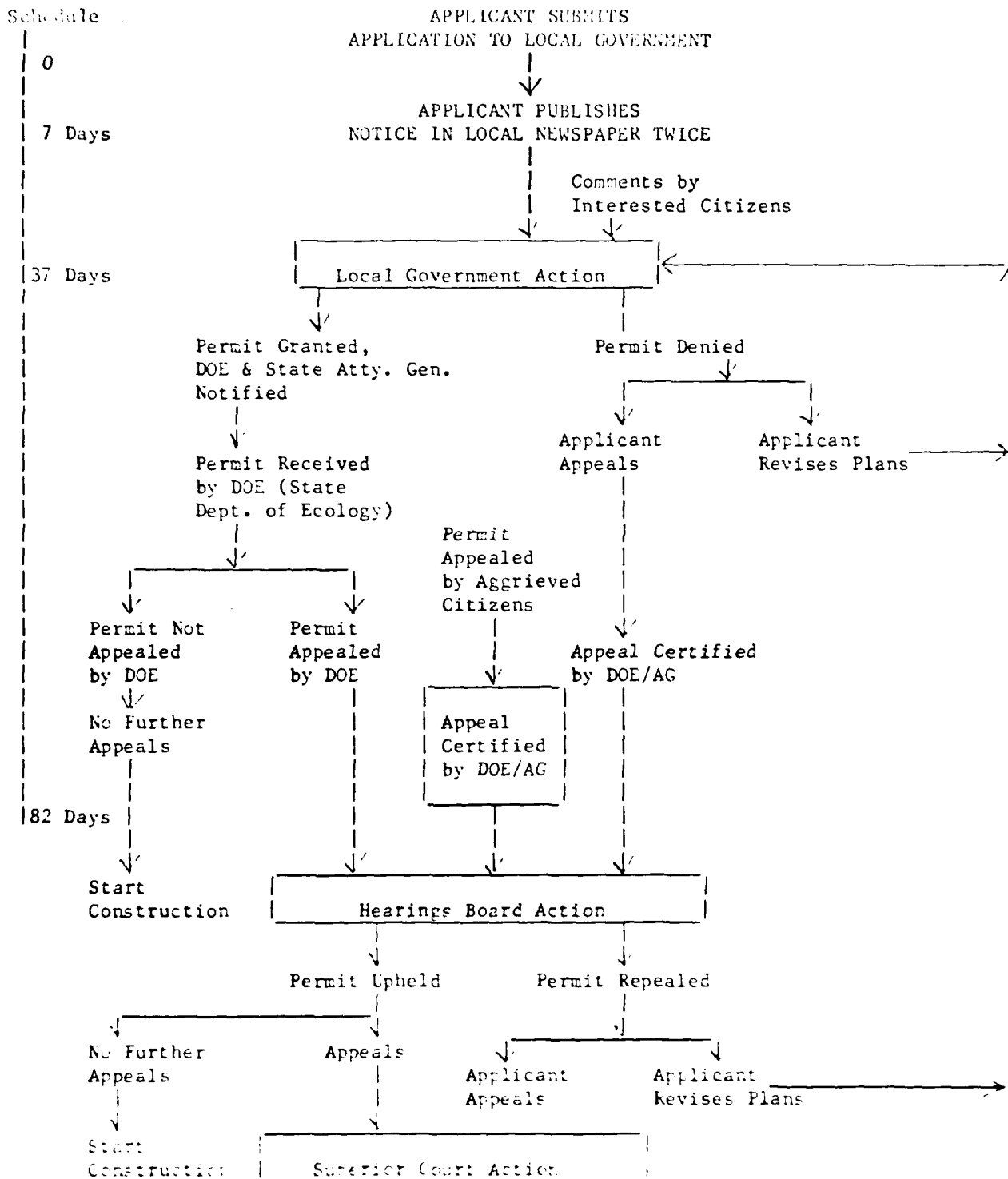
Federal Agency	Approval & License	State Agency	Action Necessary
DOE	Approval & License	Public Utilities Comm.	Set rates if applicable
DOT	Certification	Calif. Occ. Health & Safety	Permits, comment on Federal Action
C.G.		Coastal Commission	Permits concurrence objection to Federal Action
Office of Pipeline Safety			
Safety Operations Office of Development	Inspection approval & inspection	Air Resource Commission	Certificate; Comment on Federal Action
Interior			
BLM	Lease	Water Resources	Certificate; Comment on Federal Action
U.S. Geological Survey	Comment	Control Board	Certificate; Comment on Federal Action
ACOE	Permit	Fish & Game Commission	Comment on both State & Federal Action
EPA	Permit	Dept. of Navigation & Ocean Development	Comment on both State & Federal Action
Council on Environmental Quality	Comment	Solid Waste Management Board	Comment on both State & Federal Action
DOS	Comment	Parks & Recreation Division	Comment on both State & Federal Action
DOC	Comment		
National Marine Fisheries Serv.	Comment		

Continued

FIGURE 11-13: EXAMPLE OF JURISDICTION AUTHORITY & REGULATORY APPROVAL REQUIREMENT (CALIFORNIA) FOR OFFSHORE INSTALLATIONS (CONTINUED)

Federal Agency	Approval & License	State Agency	Action Necessary
Advisory Council on Historic Preservation	Comment	State Lands Commission	Permits; Comment on Federal Action
FTC	Comment	Energy Commission	Comment; Comment on Federal Action
USA & USN	Comment & Approval	Health & Welfare Office	Comment; Comment on Federal Action
Occupational Safety & Health Administration	Comment	Department of Food & Agriculture	Comment; Comment on Federal Action
ICC	Comment and approval if defined (e.g. pipeline as common carrier certification)		

FIGURE 11-14: SHORELINE PERMIT PROCEDURE



U.S./U.K. Systems

While the "growth models" of the U.S. and U.K. show little actual differences in goals, priority criteria or sensitivity to environmental concerns, there are significant differences. The most obvious and certainly the most important is that the U.K.'s model has developed its North Sea fields far faster than offshore development is even envisioned in the U.S.

Table 4 U.S. vs. U.K. Time Schedule Oil and Gas OCS Development		
Step*	U.S.	U.K.
1/2	1 year for geophysical permit	0
3	3 to 17 years to lease sale	1/2 to 3 years
4	9 to 25 years	2 to 5 years
5	11 to 25 years	3 to 6 years
*From Figure 11-15		

The U.K. system, while slighting none of the careful planning required by the U.S. system, is far more streamlined and more coordinated between public policy planning and industrial planning. However, despite American offshore oil investors' wholehearted endorsement of the speed of the British System, it should also be pointed out that the short lead time given local planners caused problems and some negative onshore impacts that perhaps could have been avoided.

U.K. was one of the first nations to produce a detailed system of licensing and control of mineral resources. The British system is relatively less complex

than the American. Since Great Britain has no formal heritage of Federalism, all mineral rights are vested in the Crown. The national government normally controls overall planning policy. Final approval and development rests in the office of the Secretary of State of Energy after consulting with the National Coal Board, Crown Estate Commissioners, Department of the Environment and the Ministry of Agriculture. The Secretary of State for Scotland has personal review authority for any major planning decision for the North Sea fields.

Additionally, broad-based organizations have been established for local planning with explicit participation of oil industry representatives as well as a special and private interest group representatives. These groups have been designed to facilitate local planning for onshore impacts so that the needs of all interested parties may be met, or at least taken into consideration.

Under the English system the following steps are necessary for OCS oil and gas exploration and developments:

1. Licenses must be secured from the Secretary of State for "searching and boring for petroleum and natural gas."

- The licenses may be made subject to any conditions dealing with the method of exploration, fees payable, model clauses or other requirements which the Secretary may prescribe.
- In 1966 the Secretary issued conditions for granting exploration and production licenses which provide very detailed codes covering all aspects of exploration, drilling, production and transportation.
- The codes divide the seabed into "landward" and "seaward" areas. The landward areas generally fall in the traditional 3 mile territorial waters. Because of the increased environmental risk of installations in the landward zone, more stringent conditions are stipulated in those licenses.

2. A production license is granted by the Secretary for an initial period of six years, but may be continued at the option of the licensee for a specified portion of the licensed area for at least 4 years, the requirement must be formally

surrendered at the end of six years.

- If ordered by the Secretary, the licensee must cooperate with other interested persons if it seems that it would be in the national interest to carry out block development and avoid unnecessary competition.

3. Planning for future developments like deepwater ports is to

- Study the question of siting with an eye to the national need. That is, place in the best spot for overall distribution, not to meet purely local needs.
- Allow the oil companies to get a fair return for their investment

(that is not as easy a question as it appears, since the companies are heavily taxed in addition to paying the Crown royalties, and their ability to freely market English oil is limited, as is their ability to compete against each other)

Ironically, given the fact the U.S. critiques of the American OSI process point at the British system as the ideal one, English analysts often argue that the American system may be a better one since it builds in more safeguards, especially for the environment, than does the U.K. system. For example:

- o Despite a clearly expressed wish on the part of Scottish coastal communities to establish an onshore developmental zone for an area of concentrated industrial growth, industry spread onshore support facilities all along the coast.
- o The result has been fairly severe environmental, social and economic dislocation in some small Scottish towns.
- o While offshore oil and gas have been developed in the English North Sea zones with no major ecological damage, many British environmentalists feel this has been as much through luck as through the environmental codes and restrictions which licensees must meet. They feel that Great Britain needs to implement the step-by-step EIS procedures which characterize the growth model presented in this section, including elaborate licensing machinery American would-be developers complain about

Regardless, it is clear that the U.K. system provides for much more technical input from offshore industry than does the U.S. At several places, for example, U.K. regulations specify only "best oil field practice." Conversely, the detailed codes provide industry with very well established guidelines based upon industry

location criteria upon which to make firm plans with a minimum of uncertainty. The central point becomes that the U.K. made a decision to develop its offshore resources as quickly as possible and saw it as in the national interest to command the buildup. The command included clear planning partnership between government and industry, a feature, as demonstrated by Figure 11-9 which is lacking at most stages of American OSI development/growth goals.

Under our present form of federalism such a command buildup is simply impossible. Indeed, at the same time, other unique features of the U.K. experience mitigate against that system's being a good model for the U.S.

- o British law and institutionalized values support a different government-industry relationship than in the U.S. Not only does the U.K. engage in far more government planning and control over the market place, but competitive behavior between individual businesses is judged by much different standards.
- o While the North Sea is a very harsh, difficult environment for OSI development, the ecology, environment, and socioeconomic structure of the impacted offshore and onshore U.K. regions were similar. They simply do not have the great variety of conditions found in U.S. offshore environments.
- It is much simpler for the U.K. to establish broadly applicable standards than for U.S. planners.

Summary

Figure 11-15 provides a step-by-step example of how the growth model functions. The specific steps in this example are those which are necessary for oil and gas development on the U.S. OCS. It demonstrates the actions/decisions made by the key actors involved at each step.

The generic steps and phases through which any proposed OCS OSI must progress are time consuming and elaborate. It is difficult, however, to see how these generic phases can be eliminated given the form of government/business relationship in the U.S., and the context of our institutionalized values. The consequences of a mistake are simply too overwhelming.

FIGURE 11-15: GROWTH MODEL: KEY DECISIONS IN THE OCS PROCESS

Step	Federal Decision	State/Local Actions or Involvement	Industry
1. (2 yr. minimum)	Preparation for Leasing		
a.	5 year tentative sale schedule established	Recommendations to Secretary of the Interior	Preparation of market and capability analyses, tentative geophysical study, preliminary location analysis of on-shore facilities
b.	Call for nominations	Response to call for nominations	
c.	Tentative tract selection		
d.	Draft environmental statement	Review and comments on draft EIS	
e.	Final environmental statement		
f.	Draft Secretary Information Document (SID) for proposed notice of sale	Review and comment on proposed notice of sale	
g.	Final SID		
h.	Final tract selection		
i.	Notice of sale		
2. (10 mos.)	Sale		
a.	Lease issued	Planning for exploration impact	Make bid

Continued

FIGURE 11-15: GROWTH MODEL: KEY DECISIONS IN THE OCS PROCESS (CONTINUED)

Step	Federal Decision	State/Local Actions or Involvement	Industry
3.	Exploration		
(1-7 yrs.)			
a.	Exploration plans, environmental report, evaluation and drilling permit approval	Comment on exploration plans, issue-reject permits for exploration onshore support facilities	Additional geophysical study, constructing of onshore support facilities, preparation of development projections, plans and financial estimates
b.	Transportation management plan. End of process if no economically recoverable discovery	Comment by affected states	Abandon lease & onshore bases if not economic
4.	Development		
(4-9 yrs)			
a.	Development and production plans, environmental reports, evaluation and approval for drilling	Response to plans, comment on EI report State/local permits for offshore facilities	Development drilling & production platforms put into place, expanded onshore support facilities initial pipeline construction
b.	Pipeline permit issuance	State/local permits for onshore pipelines	
5.	Production		
(10-25+ yrs.)			
	Monitoring & regulatory operations by:	Assess specific impacts	Operation of facilities, additional structures, onshore support as needed, regular servicing of wells platforms
	- USGS		
	- COE		
	- USCG		
	- EPA		
	- BLM		
	- OSHA		
	- DOE		
	- DOT		
	- ICC		
			Construct pipelines

Continued

FIGURE 11-15: GROWTH MODEL: KEY DECISIONS IN THE OCS PROCESS (CONTINUED)

Step	Federal Decision	State/Local Actions or Involvement	Industry
6. (1-3 yrs)	Shutdown - lease termination or expiration	Assess specific impacts	Dismantling of OCS facilities, sealing wells, closing onshore support

CHAPTER 12: THE GOVERNMENT FRAMEWORK

This chapter presents an overview of the very complex role of the federal and state governments in the marine environment. Some overlap and duplication with the material in Chapter 10 is presented, with the idea that each chapter should be self contained.

As a backdrop, figure 12-1 summarizes the functions performed by various federal agencies. With this as background, we describe in some detail those functions being performed by federal agencies that we consider most relevant: regulation, law enforcement, and research. (See also figure 2-1 in Chapter 2 of Volume I.) The second part of the chapter is a description of some of the functions performed by the states, depicting the wide variety in state performance.

I. REGULATION, LAW ENFORCEMENT, AND RESEARCH IN FEDERAL AGENCIES

This section describes the principal functions performed now and expected to continue to be performed by selected federal agencies in the particularly relevant functions of regulation, law enforcement, and research.

The functions of the Executive Branch of the federal government relevant to the marine environment can be grouped into nonmutually exclusive categories as shown in figure 12-2 below. That figure is a slight amplification of figure 2-1 in Volume I.

We selected regulation, law enforcement and research because these are the categories most likely to overlap with Coast Guard roles in the marine environment. Of the other governmental functions listed, we offer the following comments:

- o We consider "service" to be broad and ubiquitous because all agencies provide it. But the Coast Guard's service is unique; search and rescue operations are sufficiently different as not to be in conflict, competition, or overlap with the service of other agencies.

Figure 12-1: SUMMARY OF FEDERAL AGENCY ROLES

Department of Commerce

Principal coastal water legislation:

- o Coastal Zone Management Act of 1972
- o Endangered Species Act
- o Fishery Conservation Act of 1976
- o Marine Mammal Protection Act of 1972
- o National Sea Grant College and Program Act of 1966
- o Research and Sanctuaries Act of 1972--of particular interest:
 - Administration of Sea Grant Program
 - Administration of Marine Mammal Protection Act
 - Operation of National Environmental Satellite Service
 - Operation of Environmental Data and Information Service
 - Operation of National Climatic Center
 - Operation of National Oceanographic Data Center
 - Research on Weather, Marine Ecosystems, Climate Modification, Aquaculture, Andromous Fisheries Fish Gear Development
 - Provide Funds for Port Development (EDA)
 - Provide Modern, Efficient Merchant Fleet
 - Designate Critical Marine Habitats for Endang. Species

Agencies and programs:

- o National Oceanic and Atmospheric Administration
- o Office of Coastal Zone Management
- o National Ocean Survey
- o Economic Development Administration
- o Federal Maritime Administration
- o National Marine Fisheries Service
- o Environmental Data and Information Services

Principal activities:

- o Administration of CZM Act of 1972
- o Ocean Dumpsite Monitoring and Research as Required by Marine Protection Research and Sanctuaries Act of 1972

Department of Defense

Agencies and programs:

- o Department of the Navy
- o Defense Advanced Research Projects Agency
- o U.S. Army Corps of Engineers

Figure 12-1(cont'd): SUMMARY OF FEDERAL AGENCY ROLES

Department of Defense (cont'd)

Principal activities:

- o Develops and Maintains Defense and Security Capability
- o Operates Tactical Marine Systems
- o Conducts Research on Marine Weapon Systems
- o Monitors Marine Development and Use
- o Conducts Research on All Aspects of Marine Environment
- o Conducts R&D on Marine Concepts and Systems with Military Potential
- o Permits Control Over Hazards to Navigation, Shoreline Construction, and Dredging
- o Constructs and Maintains Harbor and Marine Facilities
- o Conducts Research on Navigation and Coastal Engineering

Department of Interior

Agencies and programs:

- o Bureau of Land Management
- o Fish and Wildlife Service
- o National Park Service
- o U.S. Geological Survey
- o Office of Water Research and Technology
- o Ocean Mining Administration
- o Mining Enforcement and Safety Administration
- o Heritage Conservation and Recreation Service

Principal activities:

- o Distributes Funds for Encouraging and Assisting in Recreation Planning
- o Manages Federal Submerged Lands
- o Regulates and Supervises Leasing of OCS Lands
- o Grants Right-of-Way Permits for Common Carrier Pipelines
- o Administers Various Conservation Acts
- o Performs Marine and Wildlife Studies, Federal Aid Programs for Fish and Wildlife Restoration, Technical Management Assistance, and Fishery Research
- o Identifies and Protects Significant Cultural Resources
- o Administration of National Parks and Seashores
- o Administers OCS Leases (U.S. Geo.) after BLM has Leased
- o Identification of Possible Submerged Lands Toxic Substance Disposal Sites

Figure 12-1 (cont'd): SUMMARY OF FEDERAL AGENCY ROLES

Department of Transportation

Agencies and programs:

- o Coast Guard
- o Office of Pipeline Safety
- o Office of Deepwater Ports
- o Materials Transportation Bureau
- o St. Lawrence Seaway Development Corporation

Principal activities:

- o Acts as parent agency for Coast Guard
- o Establishes and Enforces Standards for Operation of Offshore Pipelines
- o Initiates and Reviews Policies with Respect to Deepwater Ports
- o Development, Operation, and Maintenance of St. Lawrence Seaway

Department of Labor

Agencies and programs: Occupational Safety and Health Administration

Principal activities: Develops, promulgates and enforces occupational safety and health standards and regulations.

Department of Justice

Agencies and programs:

- o Drug Enforcement Administration
- o Land and National Resources Division
- o FBI
- o Immigration and Naturalization Service

Principal activities:

- o Guards Against Illegal Entry to U.S.
- o Represents U.S. in Law Suits Dealing with the OCS and On or Under the High Seas
- o Investigative Arm
- o Leadership in Drug Suppression

Environmental Protection Agency

Principal activities:

- o Regulates Ocean Dumping
- o Establishes Air and Water Quality Standards
- o Regulates Coastal Water Outfalls
- o Conducts Research on Oil Spills, on Marine Ecosystems and on Impacts of Human Activity on the Marine Environment

Figure 12-1(cont'd): SUMMARY OF FEDERAL AGENCY ROLES

Department of the Treasury

Agencies and programs:

- o U.S. Customs Service
- o Bureau of Alcohol, Tobacco and Firearms

Principal activities:

- o Protects and Collects Revenues, Prevents Smuggling; and Regulates the Flow of People, Carriers, Cargo and Mail Into and Out of the U.S.
- o Assists CG in Enforcing Regulations on Oil and Refuse Discharge in Coastal Waters
- o Eliminates Illegal Possession and Use of Firearms, Destructive Devices, and Explosives
- o Suppresses Traffic in Illicit Alcohol, Tobacco and Firearms

Federal Communications Commission

Principal activities: Regulates Common Carrier Communication Frequency Allocations

Interstate Commerce Commission

Principal activities:

- o Regulates interstate surface transport, including inland waterways and coastal shipping
- o Certif. of carriers, rates, adeq. of service, corporate mergers

Occupational Safety and Health Review Commission

Principal activities: Adjudicates safety and health cases for DOL

Federal Trade Commission

Principal activities: Reports on the competitive effects of the issuance of a license for a deepwater port and advises about OCS leases and anticompetitive matters relating to OCS and antitrust aspects of OCS Programs

National Aeronautics and Space Administration

Principal activities:

- o Conducts Research on Use of Remote Sensing Devices for Marine Related Research
- o Researches Use of NASA Management Techniques to OCS Regulations and Research

Figure 12-1(cont'd): SUMMARY OF FEDERAL AGENCY ROLES

Department of State

Agencies and programs:

Bureau of Oceans and International Environmental and
Scientific Affairs

Principal activities: Formulates and implements policies, and manages
issues and problems relating to foreign relations and fisheries,
oceans, environment and other areas

Advisory Council on Historic Preservation

Principal activities: o Comments on the existence and significance of
cultural resources in or under proposed offshore development, and on
the contiguous shoreline

- o "Operations" is performed by only a few of the federal agencies. The Coast Guard is the principal of these among the civilian agencies, and is not in competition, conflict or overlap with other agencies in this function.
- o "Development" is the one governmental function not performed by the Coast Guard and is therefore not described in detail here.

Figure 12-2: Functions of the Federal Government
Regulation--including certification and licensing
Law enforcement--including surveillance, investigations, apprehension, hearings, imposition of penalties
Research--particularly into methods of conserving or exploiting resources
Services--direct to the public or to industry
Development--of resources and/or natural capabilities
Operations--of ships, aircraft, other vehicles, stations, bridges,
Defense--of the U.S. in a military sense
Foreign relations--including such activities as international nego- tiations over fishing rights, seabed resources

Regulation

In the Department of the Interior, the Geological Survey is responsible to regulate prospecting, mining, developing and production on Outer Continental Shelf (OCS) lands.

In the Department of Transportation, the Coast Guard is responsible for regulating the following:

- Commercial vessel safety
- Port safety
- Recreational boating safety
- Bridge safety

Also in the Department of Transportation, the Maritime Administration

Bureau is responsible to issue and enforce safety standards for transportation of hazardous materials, including pipeline and intermodal means of transportation.

The Department of Energy issues and enforces regulations on the production of energy, energy source development, and energy conservation.

The Environmental Protection Administration issues regulations with respect to protection of human health and welfare, the ecosystem, and society at large; EPA regulates all matters relative to the abatement and control of pollution; this includes the air, water, noise, pesticides and other materials.

In the Department of Labor, the Occupational Safety and Health Administration (OSHA) issues regulations to protect the safety and health of members of the labor force.

In the Department of Defense, the Army Corps of Engineers issues regulations to protect the nation's rivers, waterways, lakes, and ocean and lake shores.

In the Department of the Treasury, the Bureau of Alcohol, Tobacco and Firearms issues regulations with respect to protection of the consumer, U.S. revenues, and production and distribution of alcohol, tobacco products, firearms, and explosives.

Also in the Department of the Treasury, the Customs Service regulates the imposition of duties and taxes on imported merchandise.

In the Department of Justice, the Drug Enforcement Administration (DEA) regulates the legal trade of narcotics and dangerous drugs.

Law Enforcement

In the Department of the Interior, the Mining Enforcement and Safety Administration enforces health and safety standards in coal mines and in metal and nonmetal mines.

In the Department of Transportation, the Coast Guard maintains surveillance of coastal and inland waters for violators of U.S. laws and treaties, and apprehends discovered violators. These include safety and pollution violations as well as violations of fishery laws and treaties. The Coast Guard also inspects commercial vessels and recreational boat building facilities to enforce safety standards, and enforces port and bridge safety and security regulations.

Also within the Department of Transportation, the Materials Transportation Bureau enforces safety standards for transportation of hazardous materials, including pipeline and intermodal methods of transportation.

The Department of Energy enforces regulations on the production and distribution of energy.

The Environmental Protection Administration enforces its own regulations with respect to protection of the environment against pollution.

Within the Labor Department, OSHA enforces standards of safety and health with respect to the labor force.

In the Department of Treasury, the Bureau of Alcohol, Tobacco and Firearms enforces its own regulations with respect to the production and distribution of alcohol, tobacco, firearms and explosives in the interest of federal revenues and consumer protection

Also in the Department of the Treasury, the Customs Service enforces the law with respect to the movement of merchandise into and out of the U.S.

In the Department of Justice, the DEA enforces the law with respect to traffic in narcotics and dangerous drugs.

Also within the Department of Justice, the Immigration and Naturalization Service enforces the law with respect to admission and deportation of aliens.

The Occupational Safety and Health Review Commission adjudicates contested

enforcement actions instituted by the Secretary of Labor.

The National Transportation Safety Board investigates aviation and surface transportation accidents and reviews the appropriateness of penalties imposed by the Secretary of Transportation.

Research

The National Oceanographic and Atmospheric Administration (NOAA) conducts research on weather modification and analyses of the marine ecosystem, especially in relation to ocean dumping. NOAA also provides grants for the acquisition, development and operation of estuarine sanctuaries as natural field laboratories, and NOAA promotes the development of all manner of fishery-related products.

In the Department of Interior (DOI), the Office of Water Research and Technology provides grants to states and educational institutions for research relating to water resources.

Also in DOI, the Bureau of Mines conducts research on all aspects of mining, with emphasis on coal mining. This bureau also conducts engineering evaluations with respect to conservation, development and use of mineral resources and the impact of their use on the environment.

The Fish and Wildlife Service, also in DOI, conducts a form of monitoring research over all activities that could impact on the habitat preservation of fish and wildlife, including resource development and potential causes of pollution.

The Department of Energy (DOE) is primarily is an R&D organization. DOE's major areas of research are in the following:

Fossil energy development: coal
petroleum and natural gas
in situ technology

<u>DOE (cont'd):</u>	Solar	Fuel Cycle
	Geothermal	Fission
	Conservation R&D	Environmental Safety
	Fusion	Nuclear Materials Safety and Security

In the Department of Defense, the Navy Oceanographer conducts research with respect to the ocean for potential naval applications, and explores the ocean and its boundaries.

In the Department of Justice, the Drug Enforcement Administration conducts research into methods of regulating and enforcing the drug laws.

The Bureau of Oceans and International Environmental and Scientific Affairs in the Department of State conducts policy research with respect to the scientific and technological aspects of oceans, fisheries and other areas.

The National Aeronautics and Space Administration monitors ocean conditions by satellite.

In the National Science Foundation (NSF), the Assistant Director for Astronomical, Atmospheric, Earth and Ocean Sciences conducts research related to ocean resources.

II. STATE, REGIONAL, AND LOCAL GOVERNMENTAL ROLES

The following description covers only some of the more active states. Our purpose is illustrative only. In a sense, this section amplifies the material in Chapter 11 showing the enormous amount of administrative and political detail that must be gotten through under the present state of urgency for offshore development, before action can take place.

Coast Zone Management: An Illustrative Example of Many "NO's", few "YES's"

The Coastal Zone Management Act of 1972 provides a mechanism for the establishment of state programs to protect and develop coastal waters. However, it is not

at all clear what actual powers of management or control the coastal states have over specific coastal water activities and resources. One can expect that as the planning and exploitation of such resources become increasingly important and profitable that the issues of jurisdiction will become a crucial factor between state agencies and different federal agencies.

The CZMA Act in Section 3-02 states that one goal is:

"...to encourage the states to exercise their full authority over the lands and waters in the coastal zone..."

But the "full authority" was not delineated in the Act, nor is there a uniform grouping of state agencies to draw from. It should be possible to infer state "full authority" by case studies of state development and other legislation as well as court decisions. It is clear, however, that the distribution of authority is fluid and evolving. How it evolves will impact upon future offshore development.

The table presented in figure 12-4 demonstrates the variety of state OCS programs. Examples of three fairly typical groupings of state agencies are shown in figure 12-3. Figure 12-5, drawn from California, depicts the jurisdictional, regulatory, approval authorities necessary to begin OCS development planning and construction. Figures 12-6 and 12-7--Massachusetts and South Carolina--demonstrate the complex overlap which may be involved in state oversight of operational OCS activities. They also show the very real differences between states: South Carolina's structure is far less complicated than is Massachusetts', although still far from simple. (These tables, somewhat amplified, also appear in Chapter 11.)

The impressive point that emerges is that any of the "X's" in these figures is a potential unilateral bottleneck, but few of these "X's" if any can unilaterally give a go-ahead.

Figure 12-3: GROUPINGS OF STATES SUBJECT TO IMPACT FROM OCS ACTIVITY

<u>Region</u>	<u>Divison</u> (Lease sale grps)	<u>State</u>
Northeast	New England	Maine
		New Hampshire
		Vermont
		Massachusetts
		Rhode Island
		Connecticut
South	Mid Atlantic	New York
		New Jersey
		Pennsylvania
		Delaware
		Maryland
		District of Col.
		Virginia
		North Carolina
	South Atlantic	South Carolina
		Georgia
		Florida
	Gulf	Florida
		Alabama
		Mississippi
		Louisiana
		Texas
West	California	California
	Pacific	Washington
		Oregon
		Hawaii
	Northwest	Alaska

Figure 12-4: COASTAL LAND USE PROGRAMS BY STATE

	State Wide Land Use	CZM	Wetland M	Flood Plain M.	"Critic- cal" Areas Design- ated	Shore Per- mit Pro- cedure	Regional Council Member- ship
Maine	Yes/review local	Yes	No	No	Yes	Fed./local state rev.	Yes
New Hampshire	Yes/review local	Draft	Yes	No	Yes	Fed./local state rev.	No
Massachusetts	No	Draft	Yes	Yes	No		Yes
Rhode Island	Yes	Yes	Yes	Yes	Yes	Fed./local state rev	Yes
Connecticut	Yes	Yes	Yes	Yes	Yes		Yes
New York	Yes	Yes	Yes	Yes	Yes	Fed/State	Yes
New Jersey	No	Yes	Yes	Yes	Yes	Fed/State Local Rev	Yes
Pennsylvania	Yes	No	No	No	Draft	Fed/Loc	Yes
Delaware	Yes	Yes	Yes	No	Draft	Fed/State	Yes
Maryland	Yes/review local	No	Yes	Yes	No	Fed/State Local Rev	No
Virginia	No	Yes	Yes	No	No	Fed/Local	No
North Carolina	Yes	Yes	Yes	Yes	Yes	Fed/State Local Rev	Yes
South Carolina	Yes/review local	Draft	Yes	Yes	Yes	Fed./State	Yes
Georgia	Yes	Draft	Yes	No	Draft	Fed/State	Yes
Florida	Yes/review local	Yes	Yes	Yes	Yes	Fed/State Local	No
Alabama	Yes	Draft	No	No	No	Fed/State	No
Mississippi	No	Yes	No	No	No	Fed/Local	No

Figure 12-4(cont'd): COASTAL LAND USE PROGRAMS BY STATE

	State Wide Land Use	CZM	Wetland M	Flood Plain M.	"Critic- cal" Areas Design- ated	Shore Per- mit Pro- cedure	Regional Council Member- ship
Louisiana	No	Draft	Yes	Yes	No	Fed/State	Yes
Texas	No	Yes	No	No	No	Fed/State	Yes
Washington	No(Plan- ning	Yes	Yes	Yes	Yes	Fed./lo- cal/state review	No
Oregon	Yes/review local	Yes	Yes	Yes	Yes	Fed/Local State rev	No
California	Yes	Yes	Yes	Yes	Yes	Fed/State	No
Alaska	No	No	No	No	No	Fed./State	No

Figure 12-5:

EXAMPLE OF JURISDICTIONAL MONITORING & REGULATORY APPROVAL REQUIREMENTS (CALIFORNIA) FOR OFFSHORE INSTALLATION

Federal Agency	Action Necessary	State Agency	Action Necessary
DOE	Approval & License	Public Utilities Comm.	Set rates if applicable
DOT	Certification	Calif. Occ. Health & Safety	Permit; comment on federal action
Office of Pipeline Safety Operations	Inspection	Coastal Commission	Permit; concurrence or objection to Federal Action
Office of Development Ports	Approval & inspection	Div. Resources Comm.	Certification; comment on federal action
Interior			
BLM	Lease	Water resources Control Board	Certificate; comment on federal action
U.S. Geological Survey	Comment		Comment on both state & federal action
ACOE	Permit	Fish & Game Comm.	
EPA	Permit	Dept. of Navigation & Ocean Development	
Council Environmental Quality	Comment	Solid Waste Management Board	Comment on both state & federal action
DWS	Comment		Comment on both state & federal action
DOC	Comment	Parks & Recreation Division	
National Marine Fisheries Service			Comment on both state & federal action

Figure 12-5(cont'd):

EXAMPLE OF JURISDICTIONAL AUTHORITY & REGULATORY APPROVAL REQUIREMENT (CALIFORNIA) FOR OFFSHORE INSTALLATION

Federal Agency	Action Necessary	State Agency	Action Necessary
Advisory Council on Historic Preservation	Comment	State Lands Commission	Permits; comment on federal action
FTC	Comment	Energy Commission	Comment; comment on federal action
USA & USN	Comment & approval	Health & Welfare Office Department of Food & Agriculture	Comment; comment on federal action
Occupational Safety & Health Administration	Comment		Comment; comment on federal action
ICC	Comment & approval if defined (e.g., pipeline) as common carrier certification		Comment; comment on federal action

Figure 12-6: State Agency
(South Carolina) Involvement
in offshore Development

Activity	Agency *											
	1	2	3	4	5	6	7	8	9	10	11	12
residential development	x	x	x			x	x					
ports	x		x			x						
roads, highways	x	x	x			x		x		x		
airports	x	x		x		x		x				
parking facilities		x	x			x	x					
railroads	x	x	x			x		x				
agriculture	x		x								x	
forestry			x						x			
mineral extraction	x		x			x						
manufacturing		x	x				x					
energy production	x	x	x			x	x	x				
fish and seafood process			x				x					
aquacultural			x			x	x					
commercial incentives	x	x	x			x	x					
parks	x	x	x					x				x
tourist attractions	x	x	x				x					x
cultural resources	x	x	x				x					x
marinas		x	x			x						x
boat ramps		x	x			x						x
docks and piers			x			x						x
dredge material disposal	x		x									
salvage												
underwater salvage			x		x							
artificial reefs			x			x						
impoundments			x									
sewage treatment	x		x			x	x					
solid waste disposal		x	x				x					
buildings	x	x	x				x					x
dams and reservoirs	x											
water supply	x	x	x			x						
erosion control	x	x								x		
air quality	x	x	x				x					
water quality	x	x	x				x					
wildlife & fisheries			x									

* Agencies with permitting or planning/management authority.

Figure 12-6: State Agency
(South Carolina) Involvement
in offshore Development
(cont'd)

Activity	Agency *													
	13	14	15	16	17	18	19	20	21	22	23	24	Each number represents a state agency *	
residential development					x	x								
ports														
roads, highways						x								
airports														
parking facilities														
railroads						x								
agriculture														
forestry														
mineral extraction														
manufacturing														
energy production			x	x		x	x							
fish and seafood process														
aquacultural									x					
commercial incentives														
parks	x													
tourist attractions	x													
cultural resources	x													
marinas	x					x								
boat ramps									x					
docks and piers						x								
dredge material disposal														
salvage														
underwater salvage														
artificial reefs									x					
impoundments								x	x					
sewage treatment														
solid waste disposal														
buildings														
dams and reservoirs			x											
water supply			x											
erosion control														
air quality			x											
water quality									x					
wildlife & fisheries								x	x					

* Agencies with permitting, or planning, management authority.

Figure 12-7: State Agency
(Massachusetts) Involvement
in offshore Development

Activity	Agency *											
	1	2	3	4	5	6	7	8	9	10	11	12
residential development	x	x	x	x				x	x		x	
ports	x	x	x	x	x		x	x			x	x
roads, highways	x	x	x	x			x	x				x
airports	x	x	x	x								
parking facilities		x	x	x				x				
railroads	x	x	x	x				x				
agriculture	x		x	x					x		x	
forestry			x	x			x		x		x	
mineral extraction	x	x	x	x	x	x	x	x	x	x	x	
manufacturing			x	x			x	x	x	x	x	
energy production	x		x	x	x	x	x	x	x	x	x	
fish and seafood process			x				x	x	x		x	
aquacultural			x	x			x	x	x			
commercial incentives	x		x	x								
parks	x	x	x				x		x			x
tourist attractions	x	x	x	x								x
cultural resources	x	x	x				x	x	x			x
marinas		x	x	x				x	x			x
boat ramps		x	x	x				x				x
docks and piers		x	x	x				x			x	x
dredge material disposal	x		x				x	x	x		x	
salvage			x				x	x	x		x	
underwater salvage			x				x	x	x		x	
artificial reefs			x					x	x			
impoundments			x						x		x	
sewage treatment	x	x	x	x				x	x	x	x	
solid waste disposal	x	x	x	x				x	x	x	x	
buildings		x	x	x	x	x		x				
dams and reservoirs	x							x			x	
water supply	x	x	x	x	x			x			x	
erosion control	x	x	x	x			x	x	x	x	x	
air quality	x	x	x	x	x		x	x		x	x	
water quality	x	x	x	x	x		x	x		x	x	
wildlife									x			
pipeline	x		x		x	x			x			
marine construction			x	x	x	x	x	x	x	x	x	

* Agencies with permitting or planning/management authority.

Figure 12-7: State Agency
(Massachusetts) Involvement
in Offshore Development
(cont'd)

Activity	Agency *											
	13	14	15	16	17	18	19	20	21	22	23	24
residential development	x	x							x		x	
ports	x	x							x	x		
roads, highways									x	x		
airports									x	x		
parking facilities									x			
railroads										x		
agriculture								x	x			
forestry				x		x		x	x			
mineral extraction	x	x	x			x			x			
manufacturing	x	x				x			x			
energy production	x	x		x		x			x			
fish and seafood process	x	x				x		x	x			
aquacultural						x		x	x			
commercial incentives												
parks				x					x			x
tourist attractions				x					x			x
cultural resources				x					x			x
marinas									x			
boat ramps									x			
docks and piers									x			
dredge material disposal		x		x	x				x			
salvage									x			
underwater salvage									x			
artificial reefs						x			x			
impoundments									x			
sewage treatment		x		x	x		x		x			
solid waste disposal		x		x	x		x		x			
buildings							x		x			
dams and reservoirs					x		x					
water supply		x			x		x		x			
erosion control				x	x		x		x			
air quality	x											
water quality		x			x		x		x			
wildlife						x						

* Agencies with permitting, or planning/management authority.

CHAPTER 6: INDUSTRY MOVEMENT SEAWARD

Spatial overcrowding on U.S. coast lines, especially along the northeastern seaboard, is raising the value of geography at an accelerating rate, and producing operational inefficiencies among the resident industry components. These two factors contribute to raising operating costs, which are eventually passed on to the consumer.

Although there has been no move in this direction yet, a discussion point in a number of influential circles has been the potential societal and economic value of establishing industrial units--principally but not exclusively production plants--on platforms or artificial islands offshore. Some crude beginnings along these lines have already taken place in various parts of the world, with inconclusive but somewhat promising results.

This chapter presents the context within which such a development might occur in the U.S.

The sorts of plant/installation that constitute the principal candidates include the following mutually overlapping activities:

- o Storage of high volume raw or near-raw material whose transportation cost could be significantly reduced by locations available offshore.
- o Storage of hazardous materials like LNG.
- o Production of energy-intensive products whose production process involves energy available on an offshore site--e.g. oil, gas, or OTEC energy, or possibly some other form yet to emerge, such as hydrogen.
- o Manufacturing processes with high propensity to pollute either the atmosphere or water. Many manufacturing processes have traditionally and historically been carried out in urban areas where their pollution effects are aggravated by the congestion of the area. In such cases the natural ameliorative power of the atmosphere and water bodies cannot function. Movement of such industrial plants to offshore locations could bring about economic and societal benefits simply because the vast volume of air and water in the open space of the oceans would permit nature's recuperative power to operate against pollutants.
- o Production processes based on raw materials extractable from the ocean directly. The most talked-about examples are energy-related materials like

oil and gas, and the metals available from nodules on the ocean floor. Placer deposits near shore lines also have the potential for exploitation at some future time.

- o Thermal energy storage. Most industrial activities produce a vast amount of heat energy that is either wasted or is in itself environmental contamination. One concept advanced to conserve this energy, and concurrently protect the environment from thermal pollution, is to store it as heated water in vast insulated storage tanks in the sea. The practical problems of this energy storage process have yet to be worked out, but in concept it deserves exploration.

BACKGROUND

The following factors provide the context against which industrial movement seaward is likely to occur within the U.S.:

1. The U.S. northeastern seaboard has experienced urban decay and congestion to the point of near-unacceptability.
2. Similar conditions in Europe and Japan have led to testing the concept of industrial movement seaward.
3. Environmentalist opposition to further industrialization of certain urban areas has mounted to a high level in the U.S.
4. Concurrently, environmentalist opposition to despoiling the sea environment is also strong.
5. Land costs in U.S. urban areas are escalating rapidly.
6. Huge capital investment is required to promote and install an offshore industrial complex.
7. The technology of offshore structures is well advanced. It has been cast in a shadow by the North Sea "Alexander Kielland" disaster, alleged to be the worst accident in offshore history; but this is likely to be a temporary setback.

8. In the past decade the energy potential of ocean resources has begun to come into focus; if the promise is fulfilled, the oceans will produce vast amounts of energy for use in offshore industrial plants.

9. The same is true for raw materials. If the promise that has emerged in the 1970s is fulfilled, the oceans will provide for industry large amounts of its required raw materials.

10. Water transportation is less expensive than either land or air; given a capital investment in operation, the operating transportation costs would be likely to be low, especially important for either high volume products or high volume input materials.

11. The respective roles of federal, state, and local governments vis-a-vis industry in an offshore environment is only partially established; it is yet to be determined that new industrial ventures would be sufficiently free from regulatory burdens to be incentivized to make the massive capital investments required.

THE OFFSHORE INDUSTRIAL DEVELOPMENT PROCESS

The establishment of an entire industrial complex offshore would be an immensely complicated operation, staggering the imagination in its enormity. In Chapter 11 we present a description of the process through which just one offshore installation is likely to have to pass in its growth process. An entire industrial complex would confront a process multiplied into manifold complexity by comparison. We offer here a description, abbreviated from Chapter 11, of the process through which any one offshore installation must pass. Multiplication of this process by many times will be required for an entire industrial complex.

Need/Opportunity Perceived

Within private enterprise organization, within a federal, regional, state,

or local agency, or among other institutions or private citizens development and refinement of the concept will take place. It is likely to be publicized in the media, in professional journals, trade journals, books, legislative hearings, research reports, etc. This will be followed and/or concurrently accompanied by activities like the following:

- o Research and preliminary development of concept by one or more groups with an economic or political interest.
- o Development and organization of an active interest group
- o Formalized research and development; technological feasibility established
- o Preliminary engineering studies, prototype development; testing; engineering evaluation
- o Studies to match opportunity to need; alternative actions considered
- o Economic and political feasibility assessed; sociological feasibility assessed;
- o Environmental impact assessed

Alternatives Studied

Potential decision makers will make purposeful considerations of different ways to match the opportunities with the needs identified. This will entail such activities as:

- o Reduction of alternatives to manageable number of options
- o Conclusions with respect to geographical/physical auspiciousness
- o Establishment of economic, political, and technological criteria of desirability and suitability
- o Establishment of means of measuring or assessing options against criteria
- o Assessment of options against criteria

Selection of Optimum Alternative

Key decision makers arrive at tentative decision with respect to alternative to be pursued, subject to change as events unfold, but firm enough to make initial investment of time and resources. This involves:

- o Administrative action started at federal, regional, state and local levels
- o Financial interest group operational
- o Financing action commenced
- o Coordinative network among interest groups established
- o Interest group network focussed into decision to proceed

Administrative Processing

This stage involves initiation and processing of all leasing, licensing, and other papers required at all levels of government before an offshore structure may be commenced. It includes so many items, variable so greatly with circumstance, that any "typical" listing here would not really be typical. But the type event that occurs is as follows:

- o Paper filing begun
- o Governmental reviews begun; initiator-government interaction started
- o Litigation, coordination, controversy entered
- o Approval in stages granted, with complex conditions
- o Conditions met sufficiently to begin physical activity toward construction
- o Administrative processing and interaction proceeds throughout project

Physical Operations Begun in Marine Environment

Construction resource are moved physically into the location for construction activity. This involves building a shore support base, movement of heavy construction equipment to site of offshore installation, and preliminary laying out of the structure's physical dimensions. The following sorts of activities are involved:

- o Design criteria established
- o Sites for permanent structure established
- o Structural plans--architectural and engineering--completed and disseminated
- o Construction contracts let

- o Construction teams and equipment organized
- o Operating bases ashore established
- o Prefab work commenced
- o In-place construction work begun

Construction Support System Established

The massive extent of an offshore complex requires that it be logistically supported by an extensive facility, most of which is ashore. In addition, much of the contracting work to be done downstream in the construction process will not be contracted for until well into the project. This means that an extensive administrative support system also be established. The following activities are typical:

- o Continued contracting for downstream construction and provision of equipment
- o Logistics support contract schedule established through completion of construction
- o Administrative support system established for duration of construction
- o Full scale construction support system established

Logistic Support System Construction Begun

This stage includes the actual establishment of the necessary physical facilities and logistic support systems to enable the offshore installation complex to operate after it has been completed and placed into operation. It involves such activities as the following:

- o Requirements studies completed
- o Design specifications established
- o Contracts let
- o Construction begun

Construction Completed

At this point the offshore installation complex is sufficiently completed

to permit initial operation in its designed mode. The process is an ongoing one that carries on throughout the entire construction process, but is focussed into the final stages of the work. The final steps needed to make this happen include:

- o Testing of components
- o Testing of full units
- o Acceptance of units
- o Full scale installation testing
- o Sign-off of construction and equipment contracts

Operations Begun

At this point the installation complex is ready for full scale operation in its designed mode of operating. The activities associated include:

- o Test operations completed
- o Systems debugged and smoothed
- o Logistics support systems geared up for full scale operation; debugged and rendered operational
- o Functional operations started

Steady-State Operations Established

Having completed a shakedown period, the offshore installation complex settles into the operating mode likely to be maintained throughout its life. This final process involves settling out the transients in the technical, economic, political, and social systems.

GEOGRAPHICAL DISTRIBUTION

We include this section here to retain the parallel structure of the other chapters in Volume II; the coverage, however, is extremely brief.

The region of most likely first emergence of these pressures is the northeast. Although the pressures in Europe and in Japan for an offshore industrial complex have mounted to the point of action, they are not sufficiently built up here

in the U.S. to warrant a forecast that there is any region in the U.S. where they would lead to action before the end of the century, even the crowded northeast.

THE TAILORED FORECAST

Our forecast of the external pressures operating on the fundamental elements of the growth process of an offshore installation is as follows:

Need/Opportunity Perceived

The inertial of the steady-state is strong, and is likely to inhibit more than preliminary thinking about industrial movement to seaward before the end of the century. The capital investment required is so extensive and the promise of return is still so tenuous that for most industries the attractiveness is still well off into the future.

One possibility does exist, however. This is that an established offshore installation could gradually grow into an industrial complex. As the opportunities for production of energy-intensive products in OTEC plant-ships become apparent with the forecast success of OTEC before the end of the century, the existence of a plant-ship is likely to attract other industrial activities associated with its product. Our forecast is that this is not likely to occur before the end of the century, but is likely to be well into the consideration and feasibility study phase by that time.

A major inhibiting factor is the uncertainty associated with the government-industry relationships in the offshore universe. Within territorial waters the states presumably have jurisdiction, and as long as the industrial complex under consideration were to remain within these waters, the uncertainty might be minimized; however, many of the attractive features of an offshore industrial complex derive from characteristics beyond the territorial waters, even beyond waters in which the federal government claims are clear and unambiguous.

Our perception is that we have entered an era in which administrative

bottlenecks--mostly in the form of regulatory action--have become far more than trivial blocks to progress; this is because they have reached a magnitude where they impose significant additional costs to an offshore operation, even when compared with the enormous capital investments being considered.

Driving Forces, Barriers, and Obviating Factors

Figure 6-1 depicts the driving forces, barriers, and obviating factors associated with movement of industrial complexes offshore. These items have been partially addressed in previous sections of this chapter.

The Tailored Vignette

Unlike the other chapters in this report, this chapter presents the tailored vignette in the same dimensions as already discussed, and as are shown in figure 6-1. Since our rationale has already been presented, we simply allude here to the table of probabilities and expected timing in figure 6-2 which follows figure 6-1.

Figure 6-1

TAILORED FORECAST: INDUSTRIAL MOVEMENT SEAWARD

DIMENSIONS OF FORECAST	KEY DRIVING FORCES	KEY BARRIERS	OBVIATING FACTORES
Full scale "floating cities"	Decay of urban infrastructure	Large capital investment required	Unexpected decline in population and industrial density in northeast U.S.
Storage of high volume raw materials	Public opposition to siting manufacturing plants near residential areas	Untested technology	
Storage of hazardous materials		Environmental concern for oceans	"Limits to Growth" acceptance of lower standard of living
Production of energy-intensive products	Environmental concerns	"Inertia" of a new endeavor	Military hostilities with international neighbors
Manufacturing processes with high propensity to pollute	Cost of land in urban areas	Uncertainty of government/industry relationships	Technological breakthroughs in: energy storage of hazardous materials availability of raw materials
Production processes based on raw materials extracted from ocean	Crowded conditions in urban areas		
Thermal energy storage	Resource availability in oceans		
	Energy availability in ocean		
	Low cost of water transportation		
	Feasibility tested to some degree (e.g. Europe & Japan)		

Figure 6-2: TAILORED VIGNETTE - INDUSTRY MOVEMENT SEAWARD

FORECASTS	PROBABILITIES/TIMING		
	1985-1990	1991-1996	1997-2005
FULL SCALE FLOATING CITIES IN OPERATION	L	L	L
PRODUCTION OF ENERGY-INTENSIVE PRODUCTS	L	L	L
MANUFACTURING IN HIGH POLLUTION PROCESSES	L	M	M
MANUFACTURING BASED ON RAW MATERIALS FROM THE OCEAN	L	L	M
RAW MATERIAL STORAGE	L	L	M
HAZARDUS MATERIAL STORAGE	L	L	M
THERMAL ENERGY STORAGE	L	L	L
DEEP WATER PORTS IN OPERATION	L	L	L
OFFSHORE TRANSSHIPMENT FACILITIES IN OPERATION	M	H	H
OFFSHORE AIRPORTS IN OPERATION	L	L	L
OFFSHORE INDUSTRIAL ISLANDS	L	L	L

CHAPTER 7: TRANSPORTATION AND NAVIGATION

We include in the term "transportation":

- o Commercial traffic off the coasts of the U.S. that operates internationally and along the east, west, Gulf, and Alaskan coasts of the U.S. as well as between the U.S. and its island states and territories, Hawaii, Guam, the Virgin Islands and Puerto Rico.
- o Ship and other vehicular traffic that operates between and among the offshore installations off the coasts of the U.S. or its territories.
- o Noncommercial, nonrecreational traffic that operates along the routes or in the same geographic regions--i.e. governmental vehicles, research vehicles, etc.
- o Pipelines and power and communications cables in these same regions; pipelaying processes and techniques
- o Offshore installations and structures whose principal function is support of this vehicular transportation, including deepwater ports, single point mooring complexes, mobile ports, artificial islands whose purpose is to act as focal points for the transportation operation, and submarine tunnels and conduits.
- o Navigation installations--radio aids, short range aids, long range aids, and satellite relay stations.

BACKGROUND

The following descriptors characterize U.S. oceanic transportation.

1. The dominant element of U.S. oceanic transportation is the first one named above. Domestic and foreign shipping in cargo carriers constitutes over 90% of U.S. oceanic traffic.
2. Measured in tonnage, total domestic cargo has exceeded foreign cargo by a small margin for many years, but of this domestic cargo only about 25% is oceanic; the remainder is Great Lakes and inland waterway.
3. Foreign tonnage has gradually increased as a percentage of total tonnage and will exceed total domestic tonnage by early in the 1980s.

4. Petroleum products have become the dominant cargo in U.S. oceanic transportation, accounting for about 40% of the total in the late 1970s. Coal is second at about 15% of the total, and most of this is domestic.

5. Domestic waterborne freight is about 20% of total U.S. domestic freight.

6. Up until the 1970s raw materials constituted the principal U.S. import products, while finished manufactured goods and agricultural products constituted U.S. principal export products. During the 1970s the U.S. shifted from being an exporter of petroleum products to being an importer; and during this time period also the U.S. became a heavy importer of a number of finished manufactured products, particularly autos and electronic products.

7. Blockage of the Suez Canal in 1956 led to the growth of the world's very large cargo carrier (VLCC) fleet of oil tankers whose size prohibits entry into many U.S. ports, and requires lightering of cargo from offshore to U.S. ports.

8. Traffic density in a number of U.S. ports has increased to the point that congestion both in the port's harbor and in its approaches causes significant shipping delays and collision hazards.

9. Traffic density off the U.S. east and Gulf coasts has increased in the last two decades to the point that schemes to maintain separation between traffic lanes on the high seas approaching U.S. ports has become a pressing need.

10. Offshore installations in the form of oil rigs have multiplied off the coasts of Louisiana and Texas in the Gulf of Mexico. Similar installations have been present off the coast of southern California for several years, but in relatively low density and only close to shore. In the Gulf of Mexico the number of oil rigs offshore has complicated the traffic problem and required the use of "fairways" —lanes reserved for shipping in which oil rigs are prohibited.

11. Pipelines constitute the dominant mode of transporting oil and gas from offshore rigs to shore facilities.

12. There exists a world-wide network of transoceanic electrical communications cable. The associated technology is advanced to the point that almost no depth limitation exists, and fiber optics has increased the efficiency and effectiveness of this cable significantly.

13. In contrast to communications cable, oceanic power cable is limited in both depth and distance. Power loss, personnel safety hazards, and hazards to the environment are all factors contributing to these limitations. Depths are limited to less than 4000 feet and transmission distances are limited to considerably less than 500 miles. Only a few miles of such cable exists world-wide.

14. The advent of nuclear powered cargo ships has raised an issue of port safety from the hazards of nuclear accidents with consequent radiation. There is little debate at the present time, because the nuclear powered surface ship has not come on the scene as fast as was once expected; however, the issue lies dormant, ready to emerge when and if the economic and political feasibility of nuclear powered surface ships is established.

15. The installation of navigation aids covering the U.S. coasts is mature; no significant additional geographic coverage is required. However, advances in technology--e.g. satellite navigation systems and their instrumentation--continue to occur and lead to improvements in areas covered. In addition, the increased congestion in the harbors and in the approaches to several ports constitutes a pressure toward additional instrumentation.

16. Changes in the oceanic transportation patterns, and changes in offshore installations patterns have mutually interacted to produce certain other changes.

- o Advent of the VLCCs has given rise to the need for offloading facilities within access to the VLCCs--i.e. offshore, since U.S. ports are not dredged to accommodate the VLCCs. For a time the "Deep Water Port" was seen as the answer; recently, however, some other somewhat simpler

form of offshore mooring/offloading facility has appeared to be more desirable.

- o Interest in the offshore offloading facilities--i.e. deep water ports--has been concentrated in the regions off Houston, New Orleans, and New York, the three major oil import ports of the U.S. One such port, LOOP off New Orleans, is approximately 90% completed. The apparent inability of U.S. authorities to act in concert to get additional ports started, has been attributable to political/administrative factors, environmental concerns, state and local controversies, and the burden of regulatory requirements. In addition the somewhat limited refining capacity on the east coast has contributed to the lag in stimulating a DWP off New York.
- o Increase in numbers of offshore oil rigs has led to the need for pipeline networks to carry crude from offshore to storage facilities ashore. Such networks have emerged in the Gulf of Mexico.
- o Discovery of oil beneath the sea in the arctic regions off Alaska's north slope has given rise to the need for man-made artificial offshore islands to serve the same purpose that offshore rigs serve in the more temperate waters; pipe lines are then needed to transport oil from the islands to facilities ashore.
- o Siting of offshore installations in the way of potential commercial traffic patterns on the high seas requires that these structures be marked with warnings to navigation; often the structures are in locations such that they may be marked not only with warnings, but also with aids.
- o In the Gulf of Mexico the beginnings of sea zoning have taken shape in the form of well-defined fairways in which oil rigs are prohibited because of their potential hazards to traffic.

THE TRANSPORTATION PROCESS

Cause-and-effect relationships--i.e. the linkage--between the transportation elements of the macro and marine environments on the one hand and the offshore installations universe on the other hand will take place in terms of the basic elements of the transportation process. Our tailored vignette is cast in terms of these basic elements. As they relate to the offshore installations universe,

these elements are as follows.

1. Cargo-carrying ship or barge.

On the high seas	Mooring	Collision or grounding
In approaches to a port	Loading/offloading	Repairing
Entering port	Servicing	Investigating

2. Pipelines and cables.

Laying	Inspection, maintenance and repair
Pumping/loading	Stopping leaks
Flow-through	Environmental recovery from damage

3. Logistic support facilities.

Acquisition.	Operating	Repairing after damage
Manning	Maintaining	Disposition

GEOGRAPHICAL DISTRIBUTION OF TRANSPORTATION PROCESSES

The geographical dimensions of the foregoing are as follows:

1. Traffic congestion problems center around New York harbor and its approaches, with lesser problems building up in the approaches to Philadelphia, Baltimore, Norfolk, Tampa, New Orleans, and Houston-Galveston.

2. Crude petroleum imports arrive mostly from Africa and the Middle East, and enter principally through ports in the following areas:

Portland, Me.	Houston
New York	Long Beach
Philadelphia	San Francisco
New Orleans	Puget Sound

3. Crude oil is exported from the southern coast of Alaska to the lower 48 through both tanker and pipeline.

4. The major portion of coal exports exit through Hampton Roads, with additional amounts shipped from Baltimore and other ports.

5. Petroleum products are "exported" mainly from the Houston-Galveston area, and are transported principally to U.S. east coast ports.

6. Networks of offshore oil/gas pipelines are installed in the Gulf of Mexico, and to a lesser extent off the coast of California. To date no significant installation of pipelines are laid off the east coast.

7. Virtually all U.S. submarine cable is communications cable; almost no power cable is laid on or beneath the sea bottom.

TAILORED FORECAST

Our forecast of the basic elements of the transportation function as described in the opening paragraph of this chapter is as follows. See figure 7-1.

Commercial Traffic off U.S. Coasts.

The density of this traffic will continue to increase through the end of the period of this study; the foreign and the tanker components will increase as proportions of the total.

As the century draws to a close, the volume of energy-related traffic will not decrease, but there will be visible signs that within the first few decades of the next century a decrease will in fact occur.

The relative shares of commercial traffic off the east and gulf coasts will remain heavy as compared with that off the west and island coasts .

Tanker traffic between Alaska and U.S. west coast ports will increase until about the mid 1980s, then stabilize as oil flow stabilizes, and as increasing amounts of crude are pumped via pipeline.

Figure 7-1

Economic and technological driving forces and barriers exist and operate on all potential changes, and they are not repeated here except as they have specific a

Intra-OSI Traffic

As the OSI complexes increase in number and density in the Gulf and at a slower rate off the east coast, the intra-complex traffic will also increase--probably at a rate slightly faster than the rate of increase of OSI population. Advanced and sophisticated logistic support systems involving offshore installations and their onshore components will emerge. These systems will involve personnel and material habitation and storage, repair facilities, staging and storage facilities for supplies, and eventually possibly even offshore family quarters and shopping facilities. Each element of the foregoing will add demand for transportation in some form.

Noncommercial Nonrecreational Traffic

As the commercial/industrial activities in the offshore environment accelerate, the role and activities of the government and private research institutions will increase. This in turn will feed back on itself and lead to further activities in the offshore environment associated with the OSI complexes. Each OSI complex will create a "magnet" effect on other types of activities, including governmental and private research.

Pipelines and Cables

Increased oil and gas extracted from the oceans will obviously lead to the need for means of transporting it to shore locations. This can be done only through tankers or through pipelines. Since pipelines are in most cases less expensive, these will proliferate among the OSI and between the OSI and their respective shore logistic support systems.

This demand for increased use of pipelines will lead to advances in pipeline technology and to the technologies associated with inspection, maintenance and repair of leaks and other damage.

While the offshore pipelines and cables associated with the OSI universe is at present quite limited, the expansion of this universe during the remainder of the century will lead toward the need not only for pipelines to feed oil and gas to shore locations, but also for communications and power transmission within each OSI complex and between each complex and its associated shore logistic support function.

Power transmission over long distances--e.g. beyond about 500 miles--is limited by transmission line power losses. Only with extremely high voltages (on the order of 750 KV) can this loss be significantly reduced. At these high voltages of transmission the insulation problems become significant. Therefore it is likely that the industrial complexes created by the OSI expansion will lead to demand for power transmission technologies to increase the efficiency of power transmission over long distance. Should OTEC prove economically and technologically feasible, the effect of this driving force will be increased.

Transshipment Facilities

The use of VLCCs for importing oil creates the problem that most U.S. ports are not dredged to permit these ships access. This means that the only means of getting their cargos offloaded is through offshore storage and/or lightering. While this is feasible, a more economical means of accomplishing this function appears to be the construction of some form of offloading facility offshore--like the deep water ports that have been under close scrutiny for some time. For a number of reasons, including administrative feasibility, the deep water port idea appears at the moment to be dormant, and may not be revived. However, some form of offloading facility is likely to emerge to accomodate the need for offloading the VLCCs in a less expensive manner than lightering. Artificial islands have been considered, but are not forecast to become

prevalent during the time period of this study--except possibly in the arctic. Some form of single point mooring is forecast to be finally adopted.

Navigation Installations

Increased traffic congestion and increased accident rates will lead to demand for improvements in navigation systems. These improvements will apply to navigation on the high seas as well as within the narrower waters of the approaches to ports and within the port harbors themselves. Our forecast is that toward the end of the century improvements will take the form of added electronic gadgetry based upon the Omega system or its eventually successor, as well as other satellite navigation systems. High frequency short range radar navigation devices are also likely to be developed for use in congested waters to serve both as navigation aids and collision avoidance aids.

Tailored Vignette

The following forecasts of the hardware elements of the transportation process are derived from the macro and marine environment forecasts presented in volume I, and from the data presented in the appendix to this chapter.

1. Cargo-carrying ship or barge.

The number of cargo-carrying ships and barges will continue to increase as the world's economies continue to grow. Whether the U.S. merchant marine keeps pace with overall growth rates is questionable.

The number of VLCCs will also increase; this will pressure the U.S. to develop and construct offshore offloading systems in some form. The deep water port concept appears at the moment to be economically and/or administratively infeasible, but some form of single point mooring system will be developed and installed, first in the Gulf of Mexico, and later off the east coast of the U.S.

Traffic control systems will proliferate in the ports of major congestion.

The resistance to "control" by the operators will persist, but the realism of collision hazards will lead toward slow accomodation.

Satellite surveillance, weather monitoring, navigation and communications systems will also expand their coverage. A National Oceanic Satellite System is being planned by 3 federal agencies as an operational ocean monitoring system for both military and civilian users; it is planned to be operational from a space shuttle by the mid 1980s.

Automated ship collision avoidance aids will find increased usage, particularly with the proliferation of cost-effective microprocessors.

The technology of arctic and other operations in adverse weather involving oil/gas extraction will progress. This will involve particularly handling oil/gas at transition points such as extraction-to-tanker, storage-to-tanker, tanker-to-pipeline, pipeline-to-tanker, etc. It will include modifications to barges, dredges, weather instrumentation, and ice breaking devices. A start in this direction has been made in the form of a Canadian Arctic Pilot Project to transport gas in the form of LNG by icebreaker-tanker from a near-shore LNG terminal.

Investigative technologies and techniques will advance, enabling investigators to identify contraband with increased efficiency and effectiveness.

2. Cables and pipelines.

Increases in the efficiency and effectiveness of laying and protecting cables and pipelines will occur. Burying or covering pipes and cables or tunneling will become less expensive and more feasible, as will pipelaying over hard rock formations. Inspection, maintenance and repair operations will advance significantly.

OTEC success will provide the stimulus for advances in the technology of cable developments. These advances will be made in terms of reduction of power

losses with cable length, safety of personnel in the vicinity of the cables, and protection of the environment from the consequences of damage to the cables. OTEC riser cables and power transmission cables will benefit from these advances.

The limitations of cable technology may produce barriers to the rate at which OTEC units can be constructed, and are also likely to stimulate development of OTEC plant-ships on which energy-intensive products are manufactured. This processing on site will avoid the power losses, safety hazards, and environmental hazards that would accrue from attempts to transmit large amounts of power over several hundred miles from an offshore OTEC plant to an electric grid ashore.

Expansion of the OSI universe through the remainder of the century and beyond will stimulate installation of pipeline networks among the OSI units and between these units and the onshore facilities. These networks will expand most rapidly in the Gulf of Mexico in the early years, followed by expansion off the east coast of the U.S. as the century draws to a close.

3. Logistic Support Craft and Services.

Expansion of the offshore installations universe will have the effect of multiplying the demand for the many varied craft involved in logistic support. Numbers and types of work boats will be one of the principal categories in which this increased demand is felt. The technology of underwater operations will also advance because of the increased need for inspection, maintenance, and repair operations. This increase in demand for logistic support services will lead to such subsurface developments as:

- o Working depths and time duration for divers will increase.
- o Diving systems have become increasingly complex in satisfying the demands for increasing water depths in offshore oil production. Developments have included development of the submersible decompression chamber and diving bell.
- o Complex diving equipment now includes: pressure vessels,

support structures, handling systems, subsystems for hydraulic and electrical power, communications, breathing gases, and instrumentation.

- o Successful development of commercial OTEC units will stimulate development of offshore electrical maintenance and repair facilities. These will include cable ships, reel ships, reel barges, tugs, diving facilities, and underseas emergency repair facilities.
- o Capabilities for broadcasting to the surface from greater depths are improving. Acoustic modes will predominate.
- o The use of underwater sound has proliferated. Underwater telephones are being used by divers and thousands of transponders are being used in the offshore oil and gas industry.
- o The use of remotely operated vehicles will make undersea repair work more efficient.
- o Manned submersibles are still experiencing greater use in undersea work than unmanned submersibles, also called remotely operated vehicles (ROVs). However, technological improvements in the robots are making them economically more attractive.
- o ROVs are having an increasing role in offshore petroleum operations and other work, such as torpedo recovery and scientific surveys. ROVs often perform inspection and monitoring tasks more cheaply than divers or manned submersibles, and with minimal danger to human life.
- o In the long run untethered ROVs will be used in a variety of ocean operations and will replace tethered ROVs for many tasks as advances are made in power supplies, data processing, communications, and manipulators.
- o The explosive growth in ROVs over the last 5 years has been generated by oil and gas activities which support about 90% of ROV operations.
- o Currently, inspection/monitoring accounts for about 90% of ROV offshore operations, but this should decrease as a heavy trend develops toward specialization in ROVs.
- o ROVs will be used to a greater extent in support of saturation diving.

CHAPTER 8: RECREATION/CONSERVATION

The functions under consideration in this chapter are as follows:

- o Support of health-fostering marine recreational activities in the offshore environment.
- o Promotion of animal and plant marine life beyond that required simply for economic purposes.
- o Preservation of animal and plant marine life in its natural environment.

The reason that these two superficially disparate subjects, recreation and conservation, are covered in the same chapter is that the actual activities associated with the two are very often highly complementary and mutually supportive. The major portion of both recreational and conservation activities are carried out independently of any offshore structures; for example, most recreational activity involves some form of boating fishing or swimming/diving. However, a sufficient amount of activity does take place that involves offshore structures as to warrant devotion of a short chapter to the subject.

BACKGROUND

An affluent United States has spawned a multi-billion dollar recreational industry which extends well into the offshore environment of the U.S. Accompanying this industry's growth has been public interest, reflected in use of appropriated funds, in preserving the natural environment and habitats of native U.S. wild life--both plant and animal. To date most of the funds allocated for this purpose have been allocated to projects on land. In recent years, however, increasing portions have been devoted to the marine environment. Concomitant with the growth of interest in environmental protection within the marine

environment has come extended industrial activity in this environment that both threatens it and offers opportunities for its enhancement. So a loosely coordinated U.S. policy has arisen to regulate industrial expansion while promoting recreational activities, and preserving the environment. A goal of this policy has been for these three functions to be in harmony with one another.

Some of the features of relevance include the following:

- o Numerous offshore breakwaters are installed on the coasts of the U.S. These are usually massive rock structures, constructed in the ocean parallel to the shore. They prevent waves from reaching the shore, thus reducing erosion of beach and shore areas from tidal currents and wave impact, and reducing accumulation of sediment and other materials from the seabed. Breakwaters also provide a major form of protection for boating and shipping. Many form artificial harbors for commercial shipping.
- o Shore extensions have been created from fill to extend land acreage in regions close to the sea where overcrowding has made land in short supply. These extensions have been constructed in many areas on both coasts and in the Gulf.
- o Approximately one third of the U.S. shoreline is beach area. About two thirds of this is privately owned and not available to the public. Erosion is acting to reduce the remaining areas of beach available to the public. This has motivated use of groins and offshore breakwaters.
- o A National Shore Study in 1971 by the U.S. Army Corps of Engineers revealed that erosion is likely to endanger public safety, property, wildlife habitats and historical landmarks. This has also contributed to motivation toward preservation.
- o Artificial reefs have proved to be effective fish havens and ocean plant growth areas. These reefs stimulate natural reefs that attract fish and foster their growth, and promote other organic forms of growth.
- o Offshore platforms constructed for commercial purposes stimulate marine life and attract sport fish. Off California and in the Gulf these platforms have become favorite sites for spearfishing, scuba diving and other recreational activities.
- o The living quarters on offshore oil/gas rigs or on adjacent platforms have proven the habitability of such locations, and form the basis in experience for establishment of recreational offshore hotels and other recreational habitats.
- o Concepts of marine parks and sanctuaries have gained public attention in recent years. In 1975 an International Conference on Marine Parks

Reserves was held in Tokyo. At this time the Cook Islands established the first World Marine Park at the island of Manaue, a small coral island of about eight square miles.

THE FUNCTIONAL PROCESS

The sequence of events leading to establishment and operation of an offshore installation relating to recreation or conservation is generically as follows:

Requirement/opportunity established

This event is often the by-product of some other related event--either commercial or recreational--such as growth of a marina or commercial harbor, increased activities of recreational fishermen in a given region, increased recreational population of a shoreline beach area.

A second source of initiative through which a requirement is established is observation by environmentalists or by agents of the government of erosion or damage to a coast line through natural or industrial forces.

As pointed out in the preceding paragraph, many of the offshore structures that provide recreational or conservational functions are initially constructed for commercial reasons; their recreational/conservational function is the by-product of their creation for this other purpose.

Development/Installation

This process usually takes place with less acrimonious debate within government and industrial circles than does the corresponding process for development/installation of industrial/commercial installations. This is because installations for recreational or conservation are usually placed in areas where there is little conflict with industrial or commercial functions. They are usually outside traffic lanes and near regions of low industrial activities. For this reason, once the requirement has been recognized and established for that type installation, it is likely to go forward with somewhat more dispatch than are the structures associated with oil and gas extraction

or some other industrial function. On the other hand, the requirement is usually not clearly established until well after the actual need has arisen.

Operation and Maintenance

For the most part, recreational/conservational installations are mostly inert and require little "operational" direction. Much of the maintenance function is devoted to insuring the retention of the capability originally intended. Interference with the operation or its maintenance can come from industrial activities growing up in the region, and this is the object of much of the attention given to system operation and maintenance. On the other hand, historically, the U.S. government has withstood encroachment on environmental preserves with some degree of resolution by heavy industry; only the more "protected" industries, like fishing, are likely to make much headway in encroachment. And in the case of fishing, there is little likelihood in most cases that commercial fishing will be newly attracted to an area not heretofore fertile.

Although the operation and maintenance function is relatively low key, it will nevertheless often require certain facilities. For example, boats and maintenance equipment, diving equipment and personnel, guides, and equipment operators will be required in small amounts.

GEOGRAPHICAL DISTRIBUTION

Breakwaters have been installed off the U.S. coasts, particularly the west coast where the OCS drops off quickly and there are fewer natural sheltered harbors. Almost every large U.S. port has at least one breakwater for commercial purposes; such breakwaters also serve to protect the coast line from erosion.

The following preserves have been established within the U.S.:

- o Over 30 designated marine/seashore parks. These are located in

the Pacific off Alaska, Hawaii, the Pacific Trust Territories, the Great Lakes, the Atlantic coast, the Gulf, and in the Caribbean.

- o Two officially designated marine sanctuaries have been established off the east coast.
- o One area of the U.S. National Park System has been designated as an "underwater park". This is the Buck Island Reef National Monument in the Virgin Islands.

TAILORED FORECAST

Basic Concepts: Key Dimensions of Change

The following concepts constitute the key dimensions along which fundamental change in the recreational conservational universe is likely to take place.

Requirement/Opportunity Established: The basic demand for action to develop a recreational/conservational resource is likely to correlate closely with environmental considerations. It also correlates with the general level of affluence in the U.S.--and is likely to vary with the general economic conditions. These resources find their base in venture capital and governmental appropriations, which also follow general economic conditions. This means that recreational/conservational initiatives are likely to rise and fall faster than the economy as a whole, and with some considerable time lag.

If the productivity problem confronting the U.S. economy for the last few years fails to resolve itself, we are likely to see a general reduction in the resources allocated by the economy's private and public sectors to the recreational/conservational resources.

Since the interest groups most concerned with development of the recreational/conservational resources are oriented largely in parallel with the environmentalists, it is likely that any catastrophic or near-catastrophic event that damages the marine environment will result in pressures toward conservation; a by-product may often be enhancement of the recreational resources as well.

Development/Installation: Since most if not all recreational/conservational installations are likely to be established within territorial waters, the states and local authorities will invariably have a heavily weighted input into decisions with respect to what is to be installed, when, and how. The ambiguity that surrounds decisions to install capital-intensive structures offshore beyond the territorial limits is less likely to be present in the case of the recreational/conservational installations. On the other hand, the pluralistic concerns of local and state authorities are on occasion likely to cause prolonged delays before a general agreement can be reached with sufficient consensus to permit a go-ahead.

Since complete recreational enjoyment of a marine activity usually requires free and open sea regions of some considerable geographic area, the problem of sea zoning is likely to occur. Once established, a recreational/conservational interest is likely to resist any encroachment by industry toward operations that could in any way despoil the environment.

Maintenance and Operations: An established recreational/conservational installation is likely to be reasonably free from interference from most industrial activities with the possible exception of shipping. "Freedom of the seas" could protect any shipper who suddenly found it in his best interest to establish a new shipping route that happened to intrude into a pristine region formerly reserved for recreational activities, even when this activity is within the territorial waters of the U.S.

As is true for all national parks and recreational areas, a level of alertness must be maintained at all times to insure preservation of the area's integrity and beauty.

Driving Forces, Barriers, and Obviating Factors

Figure 8-1 depicts the driving forces, barriers, and obviating factors that we forecast will operate to respectively promote, inhibit and obviate change along the dimensions of the foregoing.

The Tailored Vignette

General: The following five trends will be evident.

1. Despite pressures to exploit the marine environment for energy and other industrial purposes, the U.S. public will press for preservation and protection of the natural beauty and resources of selected areas of the marine environment.
2. This public interest will contribute toward understanding of the physics and chemistry of the oceans and their environment, and more specifically toward understanding what the natural recuperative powers of the oceans can and cannot do in protection against environmental damage.
3. Marine preserves will become as commonplace as marinas by or soon after the end of the century--depending heavily upon the state of the economy.
4. The recreational developments in the marine environment will be pursued in partnership between the federal, state, and local governments and private industry, with the federal government assuming a decreasing role as state and local governments increase their respective capabilities to handle the issues.

Artificial Islands and Land Extensions: These developments will have the following characteristics.

1. Continued beach erosion will lead to increased installation of groins and offshore breakwaters. Techniques and engineering procedures will improve the effectiveness of these breakwaters.

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OFFSHORE INSTALLATIONS AND THEIR RELEVANCE TO THE COAST GUARD T--ETC(U)

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Figure 8-1

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2. Current shorelines will continue to be extended through the use of artificial peninsulas and causeway-connected islands.

3. Offshore sand and gravel will be used for artificial island and peninsula construction because of the cost of transportation from land sources through urban regions to the intended use offshore.

4. Technological advances will be made in dredging and other construction processes involving massive amounts of earth and materials.

5. Continued economic affluence will lead to the continued expansion of marina-related structures offshore for recreational use.

Artificial Reefs and Offshore Platforms: Some of the features of these structures will be as follows.

1. Development of artificial reefs will increase at an accelerating rate during the remainder of the century and beyond. Reefs will serve the dual purpose of providing recreational activity and a depository for certain kinds of refuse not otherwise conveniently disposed of--car bodies, tires, ship hulls, etc.

2. Coordination between industry and recreational organizations will improve and promote coordinated use of offshore platforms for fishing and other recreation as well as for their industrial purposes. Improved safety and environmental protection measures will permit such recreational activities from these industrial platforms as sport fishing, sport diving pads, underwater view chambers, and rendezvous points or havens for scuba divers and skin divers.

3. The recreational fishing industry will prosper leading to overcrowding of fishing piers and shorelines, especially in metropolitan areas; this overcrowding will lead to increased demand for establishment of offshore regions for recreational fishing.

4. Artificial reefs may also find application in the development of

conditions favorable for surfing.

Underwater Chambers and Offshore Hotels/Restaurants: This is an area in which structure development in significant degree is unlikely, although an increase in general recreational activities is forecast.

1. General marine recreational activities in the U.S. will continue to grow at a rate faster than the economy in general. This means that a number of new and unexplored concepts may be tested, including offshore hotels/restaurants, and underwater tourist chambers, with tunnels/conduits providing views of undersea life. Oil platforms may be used as a basis for this type activity at some time when safety and environmental features of oil extraction have been more completely engineered.

2. By the year 2005 there will be numerous marine parks and marine sanctuaries. Some of these may have their own offshore structures.

3. New forms of marine recreation will emerge and exert pressures toward offshore facilities of some kind.

4. Economic activity in marine recreation will more than double from about \$5.2 billion in 1972 to about \$12 billion (1972 \$) by the end of the century. This activity will exert a multiplier effect on the land-side aspects of marine recreation in the form of transportation, food, and lodging.

5. Because of the rapid increase of construction cost with water depth, most of the marine recreational structures will be constructed near shore within territorial waters.

6. State and local governments will assume most of the responsibility for safety, environmental protection, and law enforcement in and among the offshore installations constructed for recreational purposes.

Figure 8-2: TAILORED VIGNETTE - RECREATION/CONSERVATION

FORECASTS	PROBABILITY/TIMING		
	1985-1990	1991-1996	1997-2005
PUBLIC PRESSURES WILL PROMOTE CONSERVATION AND BEAUTIFICATION	H	H	H
MARINE PRESERVES & SANCTUARIES WILL INCREASE IN NUMBERS	L	M	H
ARTIFICIAL ISLANDS FOR RECREATIONAL PURPOSES WILL APPEAR	L	M	M
MARINA-RELATED STRUCTURES NEAR SHORE WILL MULTIPLY	M	H	H
OFFSHORE PLATFORMS USED BY INDUSTRY WILL BE COORDINATED FOR USE FOR RECREATIONAL PURPOSES	M	H	H
STATE AND LOCAL AUTHORITIES WILL ASSUME MUCH OF THE RESPONSIBILITY FOR SAFETY AND SECURITY OF RECREATIONAL OFFSHORE STRUCTURES	M	H	H

CHAPTER 9: OCEANOGRAPHIC SCIENCE

Introduction and Context

The purpose of this chapter is to present our findings with respect to the effect on the offshore installation universe of developments in scientific research. We cover in other chapters the effects of research on the subject matter of these respective chapters; and will not duplicate that information here. This chapter focusses on basic research.

Although the results of basic research on the oceans is likely to impact directly and indirectly on the offshore installations universe, none of this research by itself is likely to impact in a substantial way immediately upon it. For example, research on extraction of energy from tidal motion would be likely to involve limited use of offshore installations in only a limited region; but the results of this research could lead to perception of opportunities for new sources of energy, and could have a heavy impact on future offshore installations.

From the point of view of research, three features of the ocean environment render it distinctive from the land environment.

- o The dynamic physical, thermal, chemical, and biological interdependence of all segments of the oceans with each other, and the close dynamic coupling of the oceans with contiguous land and atmospheric regions. This means that the oceans' characteristics can be ascertained only by studying the oceans and their land/atmospheric boundaries as a whole. There is little utility in piecemeal aggregation of the observations of a large number of independent researchers operating on isolated parts of the ocean environment. The further implication is that optimum research demands coordination not only among teams and individuals within a nation but also coordination among nations.
- o The ever-present potential hostility of the ocean environment to human presence--i.e. the potential for the ocean's weather to endanger

humans and their frail assets at any time on short notice and in any region. This means first that researchers are likely to require research instrumentation--i.e. assets--sufficiently rugged to withstand climatic forces, and second that researchers are likely to be somewhat inhibited from venturing into the oceans for research without the financial support and protection of some institutional backer--like the government or some other financially powerful institution.

- o The ambiguity of asset protection in the oceans--i.e. the limited political or legal protection of the physical assets of an individual or institution engaged in oceanic research. Firmly institutionalized concepts like "freedom of the seas" and "common heritage of mankind" render any assets in the environment subject to intrusion from outside parties whose interests conflict with the researcher's. There is only limited legal protection of the individual researcher from this source of intrusion.

The role of the federal government is also a distinctive feature of the context within which oceanic research is conducted. In defense and space programs the national interest is pursued by the federal government through planning and directing the relevant activities. In industrial developments, however, the federal government's role is necessarily different; here the role is not to plan and execute, but more to incentivize, to create an environment in which private initiatives can thrive. Since the national interest, beyond defense and space, is increasingly served through effective oceanic research, the need for industrial and commercial initiatives is high, and the government's role as creator of an auspicious environment has become crucially important. To date, the knowledge base upon which to establish policies for this role has been only partially developed.

Effective action to establish such a base is likely to come from a combination of private enterprise, the national government, and international bodies, rather than from any one of these by itself. Those nations who appear to benefit most from this coordinated research are those whose national governments take the initiative in fostering oceanic research. At the moment Japan, Great Britain, West Germany and Norway appear to have capitalized on ocean research and have advanced ocean engineering farther than has the U.S. In its last

annual report the National Advisory Committee on Oceans and Atmosphere stated that the U.S. has lost momentum in ocean engineering. The Committee held that this was the result of three factors: inadequate federal support, parochialism within the federal agencies, and inhibition of the ocean industries because of the uncertainties in federal regulation that have constrained risk taking and innovation.

TAILORED FORECAST

The remainder of this chapter is a description of the state of oceanic research today, followed by our tailored vignette--our specific forecast to the year 2005. Our description of the present state of ocean science will be presented in three subtopics. First we describe the results of a macroscopic international program in basic ocean science, the International Decade of Ocean Exploration (IDOE). Next we describe a particular development of one aspect of this macroscopic science, the results of research into how seabed minerals may be formed. We consider this topic of special relevance because of the possibility of near-term application in resource extraction from the oceans. Finally we describe the state of the art in various categories of scientific investigation at a more microscopic level. These three topics then form the basis for our tailored vignette.

The International Decade of Ocean Exploration

The IDOE was initiated by President Johnson and carried on by the subsequent administrations through the decade of the 70s. It was an application of "big science" on the scale not heretofore applied to ocean research, and reflected to some degree the awareness of the need for large scale coordination in ocean research alluded to in the previous paragraphs. In its initial stages it was driven by Presidential interest from the White House, and although this intensity of interest waned in several years, the scale of research remained large throughout the project. Since it represents a significant step forward in

several dimensions, and probably represents the most important elements of progress in the decade of the 70s, we address its accomplishments here.

The IDOE supported studies of the physical and biological aspects of the ocean, studies of the ocean floor, and studies of the relationships between the ocean and its two major environmental counterparts, the earth and the atmosphere. The research was on a scale not previously achieved, and it brought scientific understanding beyond our ability to solve the associated legal and institutional problems. Its accomplishments were in essentially three areas.

- o IDOE's scientific achievements were significant in themselves in furthering our understanding of the oceans and their environments.
- o Equally important was IDOE's achievement in promoting the maturity of large scale oceanographic project organization and management --not before attempted, and not by any means perfected even in IDOE.
- o IDOE also provided experience in bureaucratic management, including the international aspects of this management, of ocean research. This type research management is not new, but it is new to oceanographic research.

The three general areas in which IDOE made significant scientific contributions were as follows:

Physical. Understanding was enhanced with respect to the physical dynamics of the oceans. For example:

- o The feedback mechanism coupling ocean and atmosphere was studied in terms of the massive thermal and mechanical intertias involved. Understanding was sought as to how this coupling related to climate and weather. Hope exists that information being developed from this study effort will be of practical use in management of fisheries, military operations, environmental conditions, and waste disposal.
- o Correlation between deep, extensive, and previously not understood ocean pools and currents on the one hand and atmospheric phenomena on the other hand was established; however the nature of the coupling mechanism was not well established. More specifically:
 - Large scale ocean-atmospheric interactions were linked to enormous pools of temperature anomalies extending several hundred meters below the surface, measuring half mile across, and

existing for upwards of 2-3 years.

- Large and intense mesoscale eddies exist in mid-ocean of variable spatial and time dimensions. These eddies vary in size from a few meters across to several hundred kilometers, and in duration from a few days to several years.
- o Mid-ocean phenomena were linked, through their effects on coastal phenomena, to weather patterns along coastal regions, but here again the mechanisms were not clearly defined.
- o Circumpolar currents around Antarctica were linked to currents in the temperate latitudes with approximate detail.
- o A deep ocean map of circulation patterns over the globe was developed showing major characteristics of water column content in terms of temperature, salinity, oxygen, phosphates, nitrates, silica, alkalinity, CO₂, C-14, H₃, barium, and copper.
- o Correlation between solar activity and climate variability was developed, but its mechanism was not established.

Biological. Research on the macro aspects of living resources led to advances in several areas.

- o The effects of coastal upwelling on the living resource content of coastal regions was identified with some degree of specificity. Nutrient enrichment for these regions from this upwelling was clearly established and correlated with weather conditions. Regions off Peru, Oregon, and the northwest coast of Africa were studied. Concurrently the life cycles of phytoplankton and zooplankton were correlated with the cycles of upwelling; this should prove useful at some later time in that phytoplankton is the basis for the pelagic life chains which in turn constitute the basis for commercial fishing.
- o Pollutant interaction and transfer mechanisms were studied enhancing understanding of the manner in which pollutants are distributed, concentrated, and neutralized.
- o The process by which pollutants are transmitted across the air-water boundary was studied and useful information derived.
- o Sea floor chemical process were studied and their relationships to organic composition of sea water identified in some degree.
- o An important conclusion of this biological aspect of IDOE was confirmation of the recuperative power of the oceans.

Geological and Geophysical. In this area of study the physical linkage between the dynamics of the earth's crust and ecosystems was investigated and

significant findings developed.

- o The effects of mid-ocean spreading center behavior on ocean floor living and nonliving resources were studied. Insights were gained as to the behavior of tectonic plates, the relationship of this behavior to ocean floor resources, how ocean floor crust is formed, the behavior of continental margins, and the relationship of all of these to the formation of hydrothermal deposits on the sea floor.
- o Plate tectonics and its relationship to features of the seabed that seem to indicate the presence of hydrocarbons was pursued. Information gained is likely to prove useful in assessing the probability of oil or other resources in or beneath the seabed.
- o The source of deep sea nodule formation was investigated and conclusions reached concerning the conditions that may promote their formation--although no conclusions were reached as to the mechanism of formation. The relationship of nodule presence and the metal content of the nodules to geography was tentatively established.
- o The magnetic and biological properties of the seabed were studied in relationship to the changes in the earth's climate in the distant past. This was an effort to correlate cycles of seabed change to long term weather change.

Seabed Mineral Formation

One of the phenomena under study that appears to form the basis for potential future discovery of ore resources in the deep ocean deserves particular attention. This is the discovery of the manner in which ore deposits are formed in the subduction zones of tectonic plates. Portions of what is known derive from the IDOE, although much of what is known derives from independent research here in the U.S. The process is called "hydrothermal".

It has been known for some time that the regions of the mid-ocean ridges were rich in ore deposits--copper, nickel, cadmium, sulphur and other minerals. Only recently, however, has the process by which these deposits accrued been known with some degree of confidence. This knowledge is potentially useful in determining regions in which to make future exploration.

Mineral presence in the oceans appears to derive from at least three

sources. Placer deposits derive from alluvial action near coast lines. The origins of nodules on the ocean floor are somewhat uncertain, but are believed to derive directly from precipitation from the sea water over millions of years. The deposits in the mid-ocean ridge regions have recently been confirmed to derive from hydrothermal action in the earth's crust on the sea floor.

Hot springs discovered on the East Rise of the Pacific near the Gulf of California produce hot vents of water at approximately 350° C and carry in them large amounts of sulfide ore containing copper, zinc, iron, lead, silver, gold, tin, and molybdenum. As the water jet cools as it passes from the sea floor into the deep sea water, the metal ores are precipitated into concentrated accumulations on the bottom. Large accumulations have been discovered on the East Rise of the Pacific. At the moment recovery would not be economical, but the knowledge gained to date offers hope that the conditions which foster the accumulations have been ascertained in sufficient clarity to permit further search.

The conditions fostering the deposits have been determined to include:

- o High temperatures (above 350° C)
- o High pressure
- o High salinity
- o Acid content slightly higher than normal ocean water

Regions in which deposits were found were characterized by the following:

- o Tectonic plate action that rends the earth's crust on the sea floor
- o Percolation of sea water down through the fragmented crust with leaching of minerals from the rock-like crust
- o Heating of the water from the high magnum temperatures

- o Boiling of the water up through the crust and in a jet stream into the sea carrying the deposits in solution or suspension
- o Cooling of the jets and precipitation of the ores.

Aggregated Summary of Independent Research Directions

The following is a summary of the various independent research activities in governmental and private institutions that constitutes definition of the state of the art, and forms the basis for our forecast in the next section of this chapter.

Ocean resources. This research is directed toward ascertaining the nature of the ocean's living and nonliving resources, and toward means of extracting these resources, hopefully at least risk of damage to the environment. The following is an overview of the current state of this research.

- o Energy. Much of this research is well publicized and focusses on oil and gas discovery and extraction. However, some research is devoted to understanding the origins, presence, and exploitation techniques of other resources such as hydrogen and its isotopes.
- o Non-energy minerals. These include almost all the useful minerals, both in suspension in sea water and in various forms on the seabed.
- o Living resources. This research is directed toward such items as biomass, krill in the antarctic region, and more basic elements of the sea biological chain, such as phytoplankton and zooplankton.

Ocean Dynamics. Many of the characteristics of the oceans are susceptible to being used for commercial and industrial purposes, particularly in the production of energy; but because of the availability of inexpensive energy over the past many years, these characteristics have not been exploited.

- o Thermal gradients. This characteristic of the oceans is at the leading edge of this category of energy-related items. The exploitation of thermal gradients is well underway in the form of OTEC, well in advance of any of the other items.
- o Salinity gradients. The large salinity gradients at the mouths of large rivers provide large quantities of potential energy from the huge osmotic pressure difference between fresh and salt water.
- o Ocean Currents. Power generation is technically feasible by placing

turbines in the flow of ocean currents. Initial work has already been performed in the Gulf Stream.

- o Wave motion. Like ocean current power, this is technically feasible, and if the cost of energy continues to rise may become economically feasible.
- o Offshore wind systems. Again a means of extracting energy from the dynamics of the ocean environment that is technically feasible, but to date not economically feasible. Should energy costs continue to rise together with a technology advance, these systems could become operational.
- o Fuels from marine biomass. Farming of seaweed in the open ocean is still a long way from economic feasibility, but again with a continued rise in energy costs, production of methane fuel from biomass could become economically feasible at some time in the future.
- o Tidal power. The Department of Energy is examining a new concept for this conversion using dams constructed of light weight materials and compressed air as the power conversion medium.
- o Computer simulation. Research is underway to develop large simulations of ocean systems in order to augment on-site research. The data base for these simulations is in itself a major undertaking, and to date the simulations are somewhat limited.

Instrumentation. Oceanographic instrumentation is one of the major areas ongoing research, and is lagging somewhat behind the need for it. The kinds of instrumentation under development include such items as the following:

- o Automated data acquisition systems. When fully developed these systems will provide incremental improvement in our ability to profile various characteristics of the oceans.
- o Ocean conductivity measurement. This instrumentation will permit detection of conductivity anomalies in mid-ocean regions.
- o Trace metal detection. The ocean contains light concentrations of most of the elements, including metals. IDOE made significant progress in developing profiles, and this research will continue that progress.
- o Wave height measurement and surf prediction. A group in the U.K. is developing a buoy for measurement and transmission of wave height. Another group in the U.S. is developing a buoy system for predicting surf conditions.
- o Forces on offshore structures. A transducer is under development for measurement of the forces acting on offshore structures.
- o Seabed measurements in mud. Instrumentation for use in deep ocean muddy sediments on the ocean floor will enable researchers to measure pressure variations in this medium.

- o Acoustic measurements. Since acoustics is the principal means of transmitting communications signals in sea water, significant effort in development of acoustic instrumentation continues. Such items are being developed for purposes such as:
 - High data rate acoustic telemetry systems and hydrophone arrays
 - Split-beam towed sonar for acoustic measurements
 - Precision television presentations for echo ranging sonar
 - Assessing the condition of oil pipelines on the ocean floor
 - Measuring the transverse movement of sea floor gas pipelines
 - Measuring the properties of the oceans.
- o Ocean current measuring devices. Fairly intensive effort in this area is underway. Lasers, digital processing equipment, and devices for measuring deep ocean flows, boundary layer phenomena, and near-turbulent flows are under development.

Communications and surveillance. Since acoustics is virtually the only means of communicating beneath the sea surface, acoustic phenomena are the target of a great deal of research in both subsurface communications and subsurface surveillance. Above the surface of the sea, satellite and radar devices are used for communications and surveillance. They are the targets of research, but since neither need be dedicated to ocean science, the intensity of effort related directly and exclusively to ocean science is less than that devoted to acoustic means. Some of the areas of interest are as follows:

- o Sound propagation in shallow water under varying conditions
- o Acoustic transmission properties of a viscous layered boundary between a muddy bottom and the sea water
- o Detection and assessment of seismic radiation from the sea bottom
- o Effects of gravity waves in the deep ocean
- o Use of laser technology in conjunction with acoustic measurements in sea water
- o Use of geomagnetic and small scale density fluctuations in sea water to detect current variations in confined waters

- o Acoustic surveillance of fisheries. Research to date in this area is principally on measuring fish acoustic cross section and target strength, preliminary to making use of the technology for actual surveillance.
- o Development of radio (VHF and UHF) communications systems for submersibles
- o Use of fiber optic cables for communications between subsurface units
- o Use of subsurface television for subsurface surveillance
- o Fiber optics as combination telemetering and tethering cables for tethered deep sea submersibles
- o Development of advanced cables, connecting devices, and towing coupling devices for subsurface towing, tethering, and mooring
- o Advances in SeaSat technology in data processing and data distribution, for communications and surveillance; continued improvement in satellite measurement of surface winds through radiometry

Vehicles, Equipment, and Machinery. Manned and unmanned submersibles, advanced navigation and collision avoidance systems, and automated and sophisticated machinery are the object of considerable research and will continue to be into the next century. Some of the areas of coverage include:

- o Further development of the Coast Guard's Vessel Traffic Service systems
- o Development of identification, navigation, and control systems for unmanned submersibles
- o Precision of offshore spar systems for precise seafloor surveys
- o High frequency radar collision avoidance systems
- o Advanced power and propulsion units for manned and unmanned submersibles
- o Towing barges for oceanographic instrumentation in deep ocean regions
- o Metalurgy of heat exchangers
- o Advanced design manned and unmanned submersibles for such uses as
 - Work bases
 - Coring the deep ocean bottom
 - Rescue and recovery operations
 - Bottom exploration and surveillance

Environmental research. Much of the work in this area is expected to be focussed on weather measurement, prediction, and modification. Areas of concentration include:

- o Development of a system of drifting buoys for oceanographic and meteorological observation and monitoring
- o Advances in satellite weather observation, presentation and prediction
- o Global data systems for automated collection and processing of data
- o Systems for prevention and recovery of oil spills--through collection of spilled oil, combustion of oil before spreading, barriers, and other oil containment devices
- o Development of blowout protection systems
- o Environmental recuperation studies
- o Improved methods of assessing the environmental impact of new oil and other resource extraction installations in a specific geographical area
- o Same for impact of the introduction of other industrial activities into the marine environment--such as paper production, energy production, nuclear power plants, production of other industrial products
- o Development of shipboard systems with minimum environmental risk
- o Advanced design for offshore-onshore interface in production/transportation facilities--for both nonliving and living resource processing

Arctic research. The enormous resource content of the arctic and antarctic regions has been only superficially investigated until now. Polar research became a modern science during the International Geophysical Year (IGY) 1957-58. Prior to this it consisted of explorations to polar regions. Greatly expanded knowledge of the polar regions was gained from the IGY. Investigators came to recognize how little they knew about the subject. For the Arctic, U.S. research investigation is broadly divided among a number of agencies and private groups. For the Antarctic the research is centered in the National Science Foundation Antarctic Research Program.

Toward the end of the century the research intensity in these regions will multiply several times, and will extend current coverage many times over. There are obvious and highly significant differences between the two polar regions. The Arctic comprises an ocean of 14×10^6 sq. km. surrounded by land and has no large grounded ice masses except the Greenland Ice Sheet. It is characterized by appreciable land fauna and flora and is inhabited by indigenous people as well as immigrants from the south. By contrast, the Antarctic comprises a continent surrounded by the Southern Ocean totaling some 36×10^6 sq. kms. and is characterized by the Antarctic Ice Sheet representing 60% of the world's ice and has almost no land fauna or flora and no indigenous human population.

The Arctic and Antarctic also display strong similarities, including low mean annual temperatures, oceans with seasonally varying amounts of sea-ice cover, ice sheets and glaciers, alternating 6 month periods of continuous daylight and darkness at the poles, and geomagnetic disturbances and auroral phenomena.

Current interest is in areas such as the following:

- o Heat balance at high latitudes. Our knowledge of this balancing process is incomplete. The polar atmosphere-ice-ocean system is far too complex. Forecasting polar weather is difficult due to the considerable distance between stations and the fact that the world's weather is very sensitive to happenings in the polar regions. It is very possible that the world's weather over the next 10-100 years may be modulated by the Antarctic Ice Sheet surging or by ice sheet disintegration. Recent temperature changes appear to have been larger in both polar regions than elsewhere.
- o Carbon dioxide content of the atmosphere. It is believed that an increasing emission of CO_2 will cause warming. Some investigators say that the amount of CO_2 in the atmosphere will double early in the next century causing a $2-3^\circ$ warming of the world's climate with an up 7° increase at high latitudes. These changes would have a dramatic affect on the extent of Arctic sea ice and the movement of ships. In the Antarctic, warming could cause ice shelf break ups and ice sheet advances which could raise sea level by 6 m with 2 centuries although this is speculative.

- o Radio communications and solar-terrestrial physics. Radio signals can be drastically affected by charged particles emitted during solar flares and are responsible for magnetic storms. This affects radio propagation and can cause signals from VLF stations communicating with ships and subs to vary in intensity.
- o The Hydrosphere. We presently have inadequate knowledge of the physical, chemical or biological oceanography of either polar ocean. We also know little about the bottom sediments of these oceans. A real understanding of the currents in the Arctic Ocean will exist when prediction of how changes in winds, ice cover, precipitation and entrance size become possible. It appears to be years away. The living resources of the polar oceans are becoming increasingly more scrutinized with respect to the world's food supply. The adaptation of fishes to cold is of considerable interest and new information is becoming available. The difficulty of navigating in ice is an obvious deterrent to research in the polar oceans. Work is restricted to ice free areas or supplemented by air operations.
- o The Cryosphere. Drilling in the ice sheets has led to the recovery of cores that contain records of changes in the climate which in turn relate to temperature and sealevel changes as controlled by the growth of ice sheets and their return to water upon deglaciation. The possibility that Antarctic icebergs could be towed to arid regions to provide a source of fresh water has received considerable attention but little hard research. Permafrost contains ice and has posed problems for engineering projects such the construction of the trans-Alaskan pipeline. The recent discovery of offshore permafrost presents difficulties for oil and gas exploration along the coast of Alaska. More research is needed in this area.
- o International Aspects. The poles are politically sensitive areas. In the Arctic, defense considerations have very strategic implications. The principle Soviet naval base has access to the area beneath the Arctic sea ice and to the North Atlantic. These and other considerations act as a deterrent to East-West cooperation in Arctic research. There are also complex political issues involved in the Antarctic. The Antarctic Treaty is silent on resource exploitation and so a conservation regime is being worked on for the Southern Ocean. Success in this opportunity to advance both science and national interest through cooperation is a challenge for governments and scientists.
- o Additional areas in which research is ongoing in the polar regions include:
 - Assessment of living and nonliving resource content of the arctic and antarctic seas
 - Investigation of extraction means under the severe weather conditions of these regions
 - Ship movement and navigation methods to promote safety and security

- Accomodation of resource exploration and extraction operations to the ice and other adverse weather conditions of the regions
- Development of machinery and equipment specifically designed for the arctic and antarctic environment

Tailored Vignette

With the foregoing as a base, we offer the following tailored vignette--our estimate of the specific direction that science is likely to take in the dimensions of interest. See figure 9-1 for a summary of the rationale linking the concepts of the previous paragraphs with this vignette.

Note that research activity is not extensively related to offshore installations, per se; it is more related to the overall environment in which the offshore universe is embedded and operating.

The forecast categories that follow reflect in a very general way the categories of research of the preceding section.

General

The organization and management of oceanic research at the national and international level will be significantly improved, and the methods of oceanic research will be improved. This will lead to increased knowledge of the oceans as a single integrated system.

- o The relationship between the biological and physical phenomena of the oceans will be improved and will permit correlation and association of characteristics in one category with those in another during investigative and research processes.
- o The manner in which the seas are coupled with the atmosphere, with the land, and with the seafloor and shelf will be determined with an order of magnitude greater completeness than at present.
- o The relationship of ocean phenomena to weather conditions and the time lags between them will be ascertained to produce an integrated picture of the world's weather. Long term weather prediction will thus be improved.
- o The ocean's recuperative powers from manmade or natural catastrophic damage will be ascertained, enabling environmental planners to make more effective decisions. The natural characteristics of the oceans will be

Figure 9-1

TAILORED FORECAST: OCEANOGRAPHIC SCIENCE

DIMENSIONS OF FORECAST	KEY DRIVING FORCES	KEY BARRIERS	OBTAINING FACTORS
"Big" Science	Ocean resource abundance	Economic	Demise of U.S. economy
Seabed minerals	Depleting land resource supply	Conflict of interest among institutions with ocean-related interests	World-wide holocaust
Ocean resources	U.S. motivation for resource independence	Administrative bottlenecks from regulation and other procedural matters	Sudden breakthrough in resource availability from land sources
Ocean dynamics	Technology push		
Instrumentation	Perceived oil/gas reserves in OCS and beneath seabed	Lack of experience of oceanographic researchers in large scale research; preference of ocean-oriented researchers for small scale research	
Communications & surveillance	Motivation to defend against stealth in approaches to U.S.		
Vehicles, equipment & machinery	Profit opportunity in ocean resources	International conflict of interest and inability to agree on allocation of ocean's resources (UNCLOS III dilemma)	
Environmental research	Perceived world-wide food shortage		
Arctic research			

used more effectively, and more efficient man-generated environmental action will be possible.

- o The dynamics of seabed/seafloor movements and their interface with the seas will be better understood; and the multi-layered boundaries between bottom and sea will be understood. This knowledge will enhance our ability to predict conditions in both media.
- o The world system of ocean currents will be revised significantly from the models now in use, to show the large number of macro- and mesoscale eddies and other anomalies that pervade the three dimensional oceans.
- o A three dimensional model of the oceans living and nonliving resource structure will be developed on a macro scale. This will contribute to our knowledge of potential food sources in the oceans.

Ocean Resources. Our knowledge of the oceans' resources will be enhanced and enable more effective and efficient decision making by national and international policy makers.

- o The sources and production processes of seabed minerals will be identified and modeled. This will lead to understanding of likely locations, concentrations, and characteristics.
- o The relationship concentrations of living resources and mineral production activities will also be ascertained, further promoting understanding of the probable location, density, and characteristics of these living resources.
- o The location and characteristics of the oceans' resources will be correlated with other characteristics of the oceans like bottom density, current flows, temperature distributions, salinity distributions.
- o The potential of certain biological activities in the oceans to meet major portions of global requirements will be identified. For example, the krill population of the antarctic may be determined to have the potential to feed major portions of the food impoverished countries.
- o The conditions fostering growth of biological mass will be determined in significantly more detail than is now available.
- o The distribution of minerals and mineral ores will be ascertained with greater accuracy than at present --placers, sedimentary deposits, hydrothermal deposits, nodules, etc.

Ocean Dynamics. The oceans as single dynamic systems will be studied comprehensively and their inter-related characteristics more completely defined.

Such study will form the basis for greatly more efficient extraction of energy from the dynamic characteristics of the oceans. A current effort is underway now, for example, in OTEC. We forecast, however, that by the end of the century technology will be developed to produce energy in a more comprehensive and integrated manner from the ocean's energy-intensive activities. Technology will also advance to improve the conversion efficiency of energy producing equipment and machinery so that losses through inefficient heat exchangers and other equipment will be minimized. The ocean features under consideration, and in which the energy conversion efficiency improvement has potential include such factors as:

- o Salinity gradients
- o Wave motion
- o Currents
- o Wind
- o Tidal motion
- o Direct solar

Instrumentation. An area in which scientific advance is likely to be most important is that of instrumentation. This area of technology is part of one of the fastest growing U.S. industries--automation and microminiaturization of electronics. As a result our forecast is for significant advances in this area.

- o Data acquisition, processing, and reduction will become increasingly automated. Oceanographic scientific surveillance systems will be capable of acquiring vast amounts of data from diverse and distant regions, automatically process this data, and automatically analyse and interpret it.
- o Satellite systems will augment the earth-based automated systems, using advanced electromagnetic propagation techniques which permit high density transmission over a small number of channels.
- o Instrumentation advances will permit detection of chemical and physical elements in sea water, bottom mud, sediment, ocean floor ooze, and in the earth's crust beneath the soft bottom.
- o The temperature, salinity, conductivity and other characteristics of sea water will be susceptible to identification through telemetry from remotely controlled vehicles.
- o Sea and wind forces acting upon offshore installations will be susceptible

to continuing monitoring and measurement by permanently installed instrumentation. This will enhance the safety aspects of offshore structures.

- o The highly complex ocean wave systems, consisting of multiple frequencies and multi-directional vectors, will become susceptible to continuing monitoring and measurement. This will support prediction of surf conditions, beach erosion, and mid-ocean weather.
- o Sea floor instrumentation will enable scientists to measure small movements in the physical components of the sea bottom--from the relatively rapid movement of mud flows, to the extremely slow movement of tectonic plates and the earth's crust.
- o Acoustic and laser technology will advance to permit improved communications in the sea water medium, and increased accuracy of measurement of observed phenomena. Some combination of acoustic and laser technology may lead to opening a "window" in sea water through which long distance communications may be possible.
- o Computer simulations of ocean subsystems will permit sensitivity testing and analysis of large segments of ocean regions with only minimal on-site investigation.

Communications and surveillance. This area of technology will continue to advance rapidly along with and parallel to instrumentation with complementary technological bases.

- o Three dimensional surveillance systems will be available for use at much longer distances than heretofore. Holography and fiber optics techniques will find application here.
- o Surveillance of ocean boundary layers--sea to mud, mud to ooze, rock to mud, sea to air, etc.--will improve and extract scientific information which broadens the knowledge base of these boundaries. Wave transmission across these boundaries will be investigated fruitfully--not only acoustic wave motion, but extremely low frequency physical waves, as well as electromagnetic and gravity waves.
- o Turbulent and laminar layers' boundaries will be placed under surveillance with combinations of communications-surveillance instrumentation.
- o Surveillance methods will permit reception of seismic radiation from the sea floor, from which understanding of phenomena beneath the earth's crust will be enhanced.
- o Acoustic surveillance of fisheries will be developed to enable the fishing industry to ascertain the identity, location and movement of fish schools. This will promote the development of fish farming and the consequent erection of fish farm structures for selective containment of fish schools.

- o Communications linkages between submersibles will be developed that permit safe and efficient navigation at these great depths. These linkages will include fiber optics and laser communications devices as well as acoustic.
- o Fiber optics will find uses in a wide variety of communications applications in the ocean environment.
- o The surveillance capability of satellites will increase and will cover not only the sea surface, but will cover regions to several hundred feet below the surface.

Vehicles, equipment, and machinery. Many of these units will be developed in pursuit of oceanographic science, then they will find application in activities farther down stream toward engineering, production, and field operation.

- o Manned and unmanned submersibles will come into extended use, and will have the capability for deep submergence--over 4000 meters.*
- o Manned submersibles will be capable of diving to great depths and operation for extended time periods. Communication with surface control stations will be through acoustic, fiber optics or laser mechanisms.
- o Instrumentation in these submersibles will permit extensive gathering of useful data from the deep ocean regions.
- o Advanced propulsion systems will be used, such as fuel cells, long lasting electric batteries, and nuclear power.
- o Automated navigation and collision avoidance systems using sonar, inertial, and laser mechanisms will be in use for deep water and bottom navigation.
- o Operational bases will be established from which these deep submergence craft will operate.

Environmental Research. This research will focus into two major areas: weather and environmental protection/preservation. A large part of the IDOE results will be applicable.

- o Extensive effort will be expended toward establishing world-wide weather monitoring and prediction capabilities. This will include installation of systems of data collection buoys to be coordinated with satellite operations.

*During the IDOE the French American Mid-Ocean Study (FAMOUS) sent a manned submersible to 2700 meters (8900 ft).

- o A concentrated effort will be made, with considerable success, to discover ways to prevent, confine, recover, and neutralize oil spills.
- o The impact of industrial production on the environment will be well understood by the end of the century; reasonably efficient and least-cost means of controlling this impact will be available.
- o Ship systems will be designed from inception to accomodate to environmental requirements; these regulations will be institutionalized to the point of causing far less contention than they did in the first few years of environmental consciousness.
- o Similar advances will be made in the design and construction of offshore installations, both from the point of view of protection of the environment and from the point of view of safety and security of personnel and equipment; the lessons of the Alexander Kielland will be learned.

Polar Research

Progress in the advance of knowledge of arctic/antarctic phenomena and in the capability to live and operate in the severely adverse clamatic conditions of the extreme polar regions will be significant by the end of the century. Particular advances will be made in:

- o Resource extraction
- o Offshore structures/islands for oil/gas exploration and exploitation
- o Safety and security of ships in ice and other aspects of navigation
- o Machinery and equipment operations in general and in ice handling in particular

Figure 9-2: TAILORED VIGNETTE - OCEANOGRAPHIC SCIENCE

FORECASTS	PROBABILITY/TIMING		
	1985-1990	1991-1996	1997-2005
TECHNOLOGICAL PROBLEMS IN RECOVERY OF SEABED MINERALS WILL BE LARGELY RESOLVED	L	M	H
FULL UNDERSTANDING OF THE OCEANS' RESOURCES & HOW TO EXTRACT THEM WILL BE APPROACHED	L	L	M
FULL UNDERSTANDING OF HOW TO EXTRACT THE KINETIC ENERGY OF THE OCEAN ENVIRONMENT WILL BE APPROACHED	M	H	H
OCEAN RESEARCH WILL ACCELERATE AND WILL LEAD TO SIGNIFICANT INCREASES IN THE OFF-SHORE STRUCTURES OF THE OSI UNIVERSE	L	L	L
INSTRUMENTATION	L	L	L
COMMUNICATIONS	L	L	L
SURVEILLANCE	L	L	L
VEHICLES--SUBSURFACE & ROV's	L	L	L
ENVIRONMENTAL RESEARCH WILL LEAD TO SIGNIFICANT OFFSHORE STRUCTURES	L	L	L
POLAR RESEARCH WILL LEAD TO THE POTENTIAL FOR OFFSHORE STRUCTURES IN POLAR REGIONS	M	H	H
and LARGE NUMBERS OF SUCH STRUCTURES WILL BE CONSTRUCTED	L	L	L

CHAPTER 10: COAST GUARD ROLES

This chapter summarizes the roles of the Coast Guard as perceived by the study team. The purpose of the chapter is to provide an explicit backdrop of understanding of the Coast Guard's functions; misunderstanding could give rise to distortions and unnecessary contention in interpreting the results of this study effort. The chapter has four sections: a discussion of the Coast Guard's role on the OCS itself; a more general description of Coast Guard functions; a description of some of the more important relationships that the Coast Guard has with other federal agencies (in support of and complementary to the material in Chapter 12); and a general description of some of the major current issues that we perceive confront the Coast Guard and form the context for this study.

I. THE COAST GUARD'S ROLE ON THE OCS

Above and beyond the general legislative base for the Coast Guard's mission, the immediately relevant legislative base for the Coast Guard roles in the OSI universe rests on one international convention and three Congressional Acts: the 1958 Geneva Convention on the Continental Shelf; the Outer Continental Shelf (OCS) Lands Act of 1953; the OCS Lands Act Amendments of 1978; and the Port and Tanker Safety Act of 1979. The Geneva Convention establishes a form of national sovereignty over the OCS by international agreement, and the Congressional Acts assign the Coast Guard responsibility for the safety and environmental protection of the offshore area over the OCS, beyond the regions for which the individual states are responsible--i.e. the territorial seas out to three miles.

Safety of Life and Property

The principal responsibility assigned to the Coast Guard in the OCS is for

the safety of life and property on offshore structures. This responsibility has led the Coast Guard to issue regulations covering the actual construction of these structures, for the placement and adequacy of lifesaving and firefighting equipment in the structures, and for their safe operation. In order to insure that these regulations are complied with, the Coast Guard conducts periodic inspections of the structures, and investigates allegations of violations. By the OCSLA and its Amendments the Department of Interior (Geological Survey) is responsible for industrial safety on offshore structures--i.e. safety of personnel engaged in drilling and production operations. The Coast Guard coordinates with the Geological Survey in order to insure against duplication and mutual interference in the regulatory, inspection, and follow-up processes.

Navigation Safety

The Coast Guard is also responsible to insure that safe access is available to ships approaching and leaving U.S. ports. This responsibility has led the Coast Guard to establish Traffic Separation Schemes or Shipping Safety Fairways, arrangements through which ships are instructed as to traffic lanes to follow in approaching or leaving U.S. ports, and in transitting highly congested waters. The processes by which these access routes are established is administratively complex. It involves study to arrive at opimimized routes, and consultation with all users, including not only shippers, but the offshore fishing, mineral and oil industry. In addition, since foreign traffic is also involved, the process includes consultation with the International Maritime Consultative Organization (IMCO), a body of the UN, to insure international participation in the decision process.

Navigation Aids

The Coast Guard establishes the requirements, conducts periodic inspections

to insure compliance, and takes follow-up action with respect to visual, acoustic, and radar navigation aids to be installed on offshore structures.

Commercial Vessel Safety

Coast Guard responsibility for safety extends to both the physical features of offshore structures but also to the qualification of personnel. The functions performed in pursuit of this responsibility include examination and licensing of personnel, certification of the design of structural units and their equipments, and review and approval of operational procedures. The administrative processes involved in pursuit of alleged violations and investigating casualties have become extensive. Although at inception this responsibility of the Coast Guard was directed toward safety of commercial vessels, its extension to offshore structures includes mobile drilling units (the so-called Mobile Offshore Drilling Units (MODU's)), and all the logistics craft associated with the operation--supply boats, personnel boats, construction vessels (pipelayers, barges, derricks, etc.).

Environmental Protection

Coast Guard responsibility includes action to prevent damage to the environment, especially from spillage of oil or other hazardous materials. This action includes regulation, inspection, follow-up of spills to assess responsibility, and clean-up after the spillage. Coast Guard clean-up operations are conducted in conjunction with the Geological Survey.

The Coast Guard also administers an Offshore Oil Pollution Compensation Fund. This fund, established by the OCSLA Amendments, is supplied in part by oil producers in order to permit compensation for damage from oil spills. Coast Guard administers this fund through a Pollution Liability Funds Management Division at Coast Guard Headquarters.

Although the duty was established under different legislation, the Coast Guard is also responsible for licensing, design, construction, equipment and operations of U.S. deepwater ports.

Law Enforcement

As the principal operational law enforcement agency of the federal government in the marine environment, the Coast Guard is responsible to enforce all U.S. federal laws in the marine environment. These include laws regulating fisheries, smuggling of all nature (but with particular emphasis on drug smuggling), and ocean dumping. Within the jurisdiction of the states--i.e. within territorial waters--the Coast Guard coordinates with state and local authorities, but beyond these limits the Coast Guard has sole responsibility.

Protection of Offshore Assets

As the offshore universe builds up the need for its protection also increases. Protection of these assets against sabotage, terrorist attacks and other antisocial action is a joint civil responsibility of the Coast Guard and state and local authorities within the jurisdiction of the states--i.e. within 3 miles--and is the sole responsibility of the Coast Guard beyond these regions. In pursuit of this responsibility the Coast Guard exercises all the functions of a civil police force--surveillance, patrol, investigation, apprehension, and arrest. When circumstances warrant the Coast Guard acts in coordination with U.S. military forces and/or with the other agencies exercising law enforcement responsibility--such as the FBI and the Drug Enforcement Administration.

Search and Rescue

The Coast Guard's overall responsibility for safety of life at sea extends to all operations related to the OSI universe.

Relationship: OSI Universe Growth to Coast Guard

The variables associated with the growth of the OSI universe with the greatest effect on Coast Guard ability to perform its roles and missions are only indirectly related to the mission categories of offshore structures. In other words, whether an OSI is involved in oil extraction or mineral dredging is not so central to the Coast Guard as is the nature of the structure and of the operations performed on it. So the number of structures, their location, and the technologies involved in the operation of each are determining factors. As the growth in numbers extends beyond the region of state jurisdiction, the demand for Coast Guard service increases; as the technology in use on each type structure advances, the demand for Coast Guard service changes and requires additional education and training of personnel. As the OSI universe moves seaward, the geographical extent of Coast Guard coverage increases and the demand placed upon the Coast Guard increases. The nature of the product of the structures is directly important because this determines the risk of pollution, and indirectly because it determines the characteristics of the structures and their operation. As the numbers increase to the point of increasing congestion--among the structures or in commercial traffic patterns--the demand on the Coast Guard increases. In other words, the variables of the OSI universe that are most important from the point of view of the Coast Guard are: numbers, location, technology, and product.

II. THE COAST GUARD FRAMEWORK: A GENERAL OVERVIEW

The previous section addressed Coast Guard roles in specific relation to the OCS; this section describes Coast Guard functions in a more general way. Figure 10-1 is a topical description of Coast Guard structure. Following this is a general description of functions.

Figure 10-1: The Coast Guard's Structural Framework

Statutory Functions:

- o Enforce the law on and under the sea in waters subject to U.S. jurisdiction
- o Administer laws and promulgate regulations promoting safety at sea in all waters not specifically designated to another executive agency
- o Install and maintain long and short range navigational aids in coastal areas, inland waterways, harbors and military bases overseas; maintain these navigable waters ice-free, establish, maintain and operate search and rescue facilities
- o Perform oceanographic research
- o Maintain military readiness for integration with and support of Navy

Structures:

- o Navigational Systems: Safe and expeditious navigation
 - Buoys Radio Beacons Omega
 - Lights Loran C
- o Traffic Management Systems: Safe and expeditious navigation
 - Vessel traffic service (VTS)
- o Marine Surveillance: Early information for search and rescue/law violators
 - Shore, seaborne and airborne radar and visual surveillance of marine environment
- o Emergency Rescue and Assistance System: Safety of life
 - Air and surface operating bases Cutters
 - Aircraft Boats
- o Maintenance and Repair of Marine Environment System: High quality marine environment
 - Oil containment and recovery Ice breaking
 - Hazardous material containment/recovery Storm damage repair
- o Applied Research: Support to NOAA, and others
 - Laboratories
 - Data collection

Figure 10-1 (cont'd): The Coast Guard's Structural Framework

- o Military Readiness Systems: Join U.S. Navy in wartime
 - Uniformed military service Cutters Boats
 - Readiness training Aircraft
- o Administrative Law Systems: Perform regulatory function
 - Develop. of regs. Traff. cont. Bridges
 - Envir. prot. Com. ves. safety Onshore facilities
 - Drugs Ports and wtways Offshore structures
 - Deep water ports Fisheries
- o Administrative Legal System: Implement regulations
 - Licensing Inspection Boarding
 - Documentation Certification
- o Marine Law Enforcement: Enforce Law
 - Fisheries Safety by:
 - Environ. prot. Boarding
 - Drugs/smug. Inspection
 - Construction Reporting
- o Judicial System: Deter violators
 - Impose penalties and fines Prefer charges
- o Marine Management System: Effective management of these systems
 - Decision making about permissible activities in the
marine environment:
 - Fishing
 - Sealing
 - Whaling
 - Oil recovery
 - Mineral extraction
 - Aqualculture
 - Deepwater ports
 - Research and development
 - Recreational
 - Habitats
 - Port development
 - Routing traffic
- o Miscellaneous assignments: as needed and appropriate

Coast Guard Functions

According to law (14USC2) the primary duties of the Coast Guard are:

- o Enforce the law on and under the sea in waters subject to U.S. jurisdiction.
- o Administer laws and promulgate regulations promoting safety at sea in all waters not specifically designated to another executive department.
- o Install and maintain long and short range navigational aids in coastal areas, inland waterways, harbors and military bases overseas; maintain these navigable waters free from ice; establish and maintain and operate search and rescue facilities.
- o Perform oceanographic research
- o Maintain military readiness for integration with and support of the Navy during war time.

The manner in which the Coast Guard performs these duties is described below. This description is purposely without regard for the present Coast Guard organization in order to avoid bias in the research team.

Law enforcement

The Coast Guard is the federal police force with jurisdiction over seaways and waterways. Law enforcement activities are principally related to safety of life at sea to fisheries, and to protection of the environment, with the latter assuming more and more importance in recent years. Pursuit of these law enforcement activities involves:

- o Intelligence collection on illegal activities; radio, radar, and visual surveillance of sea areas from shore, from ships, and from aircraft.
- o Inspection of onshore facilities which have potential to pollute waterways.
- o Response to complaints, reports of observed violations, and requests for assistance through dispatch of aircraft and ships to the scene of violation.

- o Identification, apprehension and possible seizure of violators.
- o Containment and recovery of oil or hazardous materials that has been spilled or dumped illegally.
- o Legal proceedings against violators.

Regulation

Its original charter assigned the Coast Guard regulatory authority and responsibility with respect to safety. In more recent legislation (e.g., the Federal Water Pollution Control Act, PL 91-224) the Secretary of Transportation has been given authority and responsibility to promulgate regulations regarding environmental protection. Thus the Coast Guard has initiated proposals for environmental regulations as well as safety regulations. In point of fact, as seen by the Coast Guard, its regulatory function is one of its major functions.

Safety regulations promulgated by the Coast Guard concern ship and boat construction, with special emphasis on safety features and devices. This requires that Coast Guard personnel have a thorough working knowledge of commercial vessel and recreational boating operations and construction.

Operational Safety

The principal Coast Guard activity in the area of safety is operation and maintenance of search and rescue (SAR) ships, boats, aircraft, and shore facilities. SAR units are based along both coasts, in Alaska, and at some overseas bases. They consist of ship and boat facilities in harbors, air stations, cutters, boats, long and medium range search aircraft, and long and medium range helicopters. The search and rescue process consists of visual radio and radar surveillance of sea areas, identification of distressed units, search and location of these units,

dispatch of cutters or boats to the scene, and rescue and recovery operations on the scene.

A second safety function performed by the Coast Guard is administration and enforcement of the Ports and Waterways Safety Act. This involves maintaining cognizance of the operations and the construction relating to U.S. ports and waterways. The Coast Guard maintains a Marine Safety Office (MSO) in each major port. The Marine Safety Officer has a staff with which to insure that operations are safely conducted and that new construction meets safety standards. This function includes authority and responsibility for bridge construction, maintenance and repair as it affects navigation.

Maintenance and Repair of Marine Environment

The Coast Guard designs, installs and maintains a network of short-and long-range navigational aids and maintains navigable waterways in ice-free condition insofar as possible.

The short-range navigational aid network consists of buoys and other markers, lights, light houses and radio beacons placed in coastal waters, inland waterways, rivers, harbors and overseas naval bases. These aids constitute the principal means by which waterborne vehicles are enabled to navigate safely and expeditiously in restricted waters. The Coast Guard function includes placement, periodic inspection, repair, and replacement.

The long-range navigational aid network consists of 74 Loran C stations and two Omega stations. Loran C systems are open-ocean navigation systems that aid ships in positioning themselves in transoceanic voyages. The stations are placed to cover most of the heavily traveled Atlantic and Pacific sea routes. Omega systems are satellite aided systems that supplement the Loran C network.

Oceanographic Research

Coast Guard activity in this area is largely data collection in support of

research being done by other agencies, such as the National Science Foundation, and the National Oceanographic and Atmospheric Administration.

Military Readiness

By law, the Coast Guard shifts from DOT to DOD in time of war. A by-product of the Coast Guard's peace-time operation is a degree of military readiness. Coast Guard military readiness is further enhanced by installation of U.S. Navy weapons and sensors in its ships and aircraft (paid for by the Navy), and by minimal training in the use of these weapons and sensors.

The most use of Coast Guard units in conjunction with the Navy was in the Southeast Asia conflict where cutters very effectively assisted in naval operations. It is anticipated that more intense hostilities, such as World War II, would lead the Coast Guard into extensive activity in port safety and security.

III. OTHER RELATED FEDERAL AGENCY ROLES

This section describes the other major federal agencies' roles as they relate to and may overlap or conflict with those of the Coast Guard. We offer somewhat more extensive discussion of the Department of the Interior because of its high involvement in OCS development.

This material to some degree duplicates that in Chapter 12, where additional detail will be found; we believe, however, that this duplication is warranted to place Coast Guard roles in context here.

Department of Transportation

Office of Deepwater Ports - Initiates and reviews policies with respect to deepwater ports. Under the provisions of the Deepwater Ports Act of 1974 the

Secretary of Transportation is the principal agent of the government to execute the Act's provisions and purposes to:

- o Authorize and regulate the location, ownership, construction, and operation of deepwater ports in waters beyond the territorial limits of the United States;
- o Provide for the protection of the marine and coastal environment to prevent or minimize any adverse impact which might occur as a consequence of the development of such ports;
- o Protect the interests of the United States and those of adjacent coastal states in the location, construction, and operation of deepwater ports;
- o Protect rights and responsibilities of states and communities to regulate growth, determine land use, and otherwise protect the environment in accordance with law.

Under the provisions of this Act the Secretary is specifically authorized to issue licenses for construction of each deepwater port, after thorough and careful scrutiny of the many and varied aspects and implications involved. The Office of Deepwater Ports (ODP) in DOT is the Secretary's principal executive agent for this licensing. If the Coast Guard's role is its conventional one, it will be concerned almost exclusively with safety and environmental protection, leaving other aspects of licensing procedures, such as social, economics, and political, to the ODP.

Materials Transportation Bureau (MTB) - This bureau coordinates the Department's overall operational responsibilities with respect to transportation of hazardous materials. It is a regulatory bureau with cognizance over all transportation modes, including pipelines.

Saint Lawrence Seaway Development Corporation - This is a self-sustaining corporation financed by tolls charged for the use of its facilities. It is responsible for the development, operation and maintenance of the Seaway between

Montreal and Lake Erie, within U.S. territorial limits. The Seaway Corporation is chartered to provide a "safe, efficient, and effective waterway for maritime commerce."

Department of Defense

Corps of Engineers, U.S. Army - The Corps of Engineers is responsible for the comprehensive management of the nation's water resources, including pollution abatement, development, construction and maintenance of dams, reservoirs, levees, harbors, waterways, locks and others.

Oceanographer of the Navy - This agency is responsible to pursue research development and engineering in all aspects of ocean science, including underwater search and rescue.

Department of Commerce

Maritime Administration - The Maritime Administration (MarAd) is the federal agency responsible to promote and develop a U.S. Merchant Marine. MarAd executes its mission through subsidies to effectively make the cost to U.S. business of (1) operating and (2) constructing commercial vessels competitive with the cost of foreign operations or construction. MarAd also constructs or supervises the construction of merchant type vessels for the federal government.

National Oceanic and Atmospheric Administration - NOAA's mission is to "explore, map, and chart the global ocean and its living resources, to manage, use and conserve those resources and to describe, monitor, and predict conditions in the atmosphere, ocean, sun, and space environment, issue warnings against impending destructive natural events, develop beneficial methods of environmental modification, and assess the consequences of inadvertent environmental modification over several scales of time." These responsibilities include issuance of

navigation charts for use in commercial, naval and recreational navigation.

Department of Interior

In 1953, the Outer Continental Shelf (OCS) Lands Act (67 Stat. 462) was passed establishing federal jurisdiction over the submerged lands of the continental shelf seaward of state boundaries. The Act charged the Secretary of the Interior with the responsibility for the administration of the mineral exploration and development of the OCS. It also empowered the Secretary to formulate regulations to meet the provisions of the Act.

With respect to this authority, the Department adopted three overall minerals management goals:

- o Receipt of fair market value for the minerals leased
- o Orderly development of resources
- o Protection of the environment

The Submerged Lands Act (67 Stat. 29) set the inner limit of authority of the federal government by giving the coastal states jurisdiction over the mineral rights in the seabed and subsoil of submerged lands adjacent to their coastline out to a distance of three nautical miles. There are two exceptions, Texas and the Gulf Coast of Florida, where jurisdiction extends to three (3) leagues based upon colonial charter.

Subsequent to the passage of the OCS Lands Act of 1953, the Secretary of the Interior designated the Bureau of Land Management (BLM) as the administrative agency for leasing submerged federal lands, and the Geological Survey for supervising production. This bureau, inter alia, administers the mineral resources connected with the submerged lands of the outer continental shelf. Bureau programs provide for the orderly development, use and protection of these natural resources.

In 1969, the National Environmental Policy Act was implemented. This Act requires all federal agencies to utilize a systematic, interdisciplinary approach that will insure the integrated use of the natural and social sciences in any planning and decision-making which may have an impact upon man's environment. The BLM efforts in this direction are Environmental Impact Statements (EIS), environmental assessment teams, environmental studies, literature surveys, socioeconomic studies, public conferences on problems affecting man's environment, and special studies that contribute to an understanding of the processes affecting this environment.

Congressional Appropriations Acts give to BLM those monies required to carry out its required tasks. This probably is the strongest piece of legislation for any program, because it reflects the administration's desire to have a program administered by a certain agency, and it also shows Congressional approval.

To satisfy the requirements of these Acts the Bureau of Land Management has outlined broad programs for leasing, impact analyses (environmental and socioeconomic), and environmental studies.

The nature of coordination between the BLM and the Coast Guard in BLM's leasing role, and between the Geological Survey and the Coast Guard in CG's "supervisory" role is somewhat ambiguous, but is susceptible to incremental de facto clarification as a result of day-to-day operations.

Office of Water Research & Technology (OWRT) - The fundamental purposes of OWRT are "to develop new or improved technology and methods for solving or mitigating existing and projected State, regional, and nation-wide water resource problems; to train water scientists and engineers through their on-the-job participation in research work; and to accomplish water research coordination and

research results information dissemination activities."

Ocean Mining Administration - This agency is responsible "for policy development for the promotion and continuation of a domestic ocean-mining capability in deep seabed areas. Additional responsibilities include jurisdictional issues in international negotiations relating to the resources of the continental shelf; the implementation of a domestic ocean mining program with special emphasis on its relationship to ongoing and future negotiations on the law of the sea and ocean mining; supervision of ocean minerals economic, technology and resource assessments; supervision of ocean mineral resources environmental studies; and liaison with other Federal agencies concerned with ocean mineral resources development and regulatory aspects of ocean mining."

Fish and Wildlife Service - This service "provides leadership" in the protection and improvement of water environments for the benefit of living natural resources. Its role is more advisory than regulatory, although it is empowered to deny permits approved by the COE.

Geological Survey - This agency has many functions, among which are to enforce departmental regulations relating to gas, oil and other mining licenses and development contracts. The agency supervises the operation of private industry oil, gas and mineral leases on the outer continental shelf in order to protect the environment and prevent waste of resources.

Mining Enforcement and Safety Administration - This agency enforces public laws and health standards governing the health and safety of personnel engaged in mining operations.

Department of Labor

Occupational Safety and Health Administration (OSHA) - OSHA develops, promulgates, and enforces occupational safety and health standards and regulations.

Department of Justice

Land and Natural Resources Division - This Division represents the U.S. in law suits relative to the outer continental shelf, and on or under the high seas. These suits include especially those concerning rights in minerals, oil reserves, and other natural resources of the Outer Continental shelf.

Federal Bureau of Investigation - The FBI is the principal investigative arm of the federal government. Its jurisdiction includes the criminal, civil and security fields.

Drug Enforcement Administration - This administration enforces the law and associated regulations with respect to controlled substances, and brings to the criminal and civil justice system suspected offenders, including those involved in distribution of controlled substances destined for illicit traffic in the U.S. The DEA mission implies a role of leadership in drug suppression programs both nationally and internationally.

Immigration and Naturalization Service - This service guards against illegal entry into the U.S., and also collaborates with other agencies in stemming the flow of illegal drugs.

Department of State

Bureau of Oceans and International Environmental and Scientific Affairs - This bureau formulates and implements policies and proposals with respect to

the scientific and technological aspects of foreign relations, and also manages issues and problems related to oceans, fisheries, environment and other areas.

Department of Treasury

U.S. Customs Service - This service protects and collects revenue, prevents smuggling, and regulates the flow of people, carriers, cargo and mail into and out of the United States. Customs also assists the Coast Guard in enforcing regulations with regard to oil and refuse discharged in coastal waters.

Bureau of Alcohol, Tobacco and Firearms - This bureau attempts to eliminate illegal possession and use of firearms.

Bureau of Alcohol, Tobacco and Firearms - This bureau attempts to eliminate illegal possession and use of firearms, destructive devices and explosives, and to suppress traffic in illicit alcohol, tobacco and firearms.

Department of Energy

Performs and subsidizes research on and under the seabed. Responsibility is to insure that an adequate supply of energy is available to the U.S. This entails development and implimentation of policies and programs to increase production of petroleum and natural gas, including activities on the outer continental shelf. DOE is a regulatory agency with respect to energy production and allocation. It also coordinates international energy activities.

Environmental Protection Administration (EPA)

EPA endeavors to reduce and control pollution of all aspects of the environment--land, air, water. EPA's activities are specifically addressed, inter alia, to the quality of the nation's water through regulation and control of effluents, discharges, spillages, and dumping.

IV. TRENDS AND ISSUES

From the point of view of research on the Coast Guard, without regard for its involvement in the expansion of the OSI universe, the following trends and issues appear to form the context in which any implications or recommended action in relation to this expansion will be embedded.

1. The U.S is gradually extending its interest in and jurisdiction over the outer continental shelf and the ocean region out to 200 miles from our coast. The Marine Fisheries Conservation Act of 1976 went into effect on March 1, 1977 and asserts U.S. authority over fishing operations out to 200 miles. Project Independence is a federal effort to promote the energy independence of the U.S. It includes, inter alia, exploitation of the energy beneath the seabed of the outer continental shelf. The Deep Water Port Act of 1974 reflects U.S. interest in promoting the construction of at-sea ports for supertankers and other large commercial vessels. Two such ports got started in the Gulf of Mexico, and one is under construction. More DWP's are not likely, but some form of offshore transshipment facility is almost certain; many are in operation throughout the world.

2. This Deep Water Port Act and other legislation tasks the Coast Guard with providing operational, technical, regulatory and enforcement personnel and facilities to ensure safe transportation, storage, and utilization of energy products within the marine and adjacent shore environment. This trend of increased interest and jurisdiction over the sea out to 200 miles is reflected in the activities and responsibilities of a large number of federal agencies in addition to the Coast Guard, as shown in the previous section. The trend is already having an impact on the Coast Guard by imposing additional surveillance and law enforcement requirements on it. We may expect the trend to continue at least through the remainder of the century as other nations follow suit.

3. Associated with the trend toward an increased zone of U.S. interest at sea is a somewhat compensatory trend toward state responsibility for regulation and law enforcement in inland and contiguous waters. The "Coastal Zone Management Act of 1972" reflects this trend. The trend is particularly evident with recreational boating safety, both in construction and in boating operations. The Coast Guard is gradually shifting its cognizance over these matters to the states.

4. The oil reserves on the north coast of Alaska are being developed for transportation by pipeline to ports on the south coast, where it is further transported by tankers. This development adds to the Coast Guard requirement for surveillance, environmental protection and law enforcement.

5. a. U.S. policy is to exert increasing attention to protection of the environment, including the sea, seabed, coastal areas, harbors and waterways. An increasing body of laws and regulations reflect this trend. The Coast Guard is the federal government's maritime law enforcement agency. Therefore, this trend will also increase the load on the Coast Guard.

5. b. One aspect of federal environmental protection policy holds pollution violators accountable for reimbursing the government and other victims damages. The energy shortage has resulted in an increase in shipping of hazardous materials (e.g., LNG) and thereby in the risk of pollution. This trend also impacts on Coast Guard administration of its law enforcement function.

6. The long term GNP of the U.S. and of other developed nations is increasing. This means an increase in virtually all of the activities in which the Coast Guard has an interest--recreational boating, number of commercial and recreational vessels being built, density of commercial traffic at sea and on inland waterways, illegal traffic, number and size of ports. The general trend results in several other trends.

- o The amount of Congressional legislation affecting the Coast Guard--in terms of assigning responsibilities--is becoming very large.
- o Traffic density in large U.S. ports is demanding a form of control for safety reasons, analogous to control of aircraft at airports. The number and use of Coast Guard Vessel Traffic Service systems is increasing.
- o The need for extending the shipping season in northern waters is increasing. This is resulting in increased demand for Coast Guard ice breaker operations, especially in the Great Lakes and the St. Lawrence Seaway.
- o A change is visible in complexion of Coast Guard operations. Law enforcement operations are increasing with respect to fisheries and environmental protection off the northeast coast, off Washington, Oregon and Alaska, and off Florida in the Gulf of Mexico. Law enforcement with respect to drug traffic is increasing in the Gulf of Mexico. Ice breaking operations will increase off Alaska and possible in the Northwest Passage.
- o The U.S. Merchant Marine carries only a small share of the transoceanic cargo to and from U.S. ports. Coast Guard inspection, safety enforcement (for people and hazardous materials) and environmental protection action will increase with regard to foreign commercial vessels.
- o Federal government concern for energy conservation and resource development and for the environment has resulted in a mountainous proliferation of regulations implementing legislation. The Coast Guard itself issued some 300 regulations in 1975. In the years ahead, coordination of these masses of regulation will pose a problem.
- o The balance between competitive and cooperative forces in international shipping appear to be shifting in favor of the latter. The developing nations appear to be getting away from the direct impact of market forces, and moving toward bilateral and regional arrangements for cargo pooling and allocation. The UNCTAD is fostering this trend.

7. In 1967 the Department of Transportation was formed and immediately acquired the Coast Guard from Treasury as a subordinate agency. This equated to a very significant change in the political atmosphere in which the Coast Guard operated. In Treasury the Coast Guard was virtually autonomous, mainly because its functions were so different from those of the rest of Treasury. On the other hand, in Transportation the Coast Guard finds itself a candidate to assume a more comprehensive role as a transportation manager than appears to fit well

with its more traditional role as a uniformed military service. DOT's mission is to play a very active role in managing U.S. transportation. To this end several "modal managers" have been established; the Federal Highway Administration, the Federal Railway Administration, and the Federal Aviation Administration. These modal managers make decisions with respect to the development and allocation of transportation resources in their respective fields. There is no modal manager for the nation's water mode, but there are heavy pressures within DOT to establish one. The Coast Guard and the Office of Deep Water Ports come closest to performing the function. At the moment it appears that, should the Coast Guard seek such an assignment, the Secretary is likely to make it. However, it appears to the Coast Guard inconsistent with its role as an operating uniformed military service.

Since the mid 1970's a number of trends and issues have appeared to be emerging:

- o As portrayed in paragraphs above, there are many federal agencies with responsibilities either overlapping or impinging upon Coast Guard responsibilities specifically, and water modal management in general. This fact is likely to lead to complications in the development of a water mode management policy.
- o Recent developments in ocean shipping are leading to "utilized" cargo systems and cross-modal terminals which promise significantly more efficient intermodal through-put. These developments also are leading the transportation industry toward becoming more capital-intensive than labor intensive. This in turn may lead to reducing the comparative disadvantage of the U.S. in competition with lower cost labor nations.
- o The innovations alluded to above, especially the advent of the supertanker, are likely to lead to significant increase of the federal role in port development, whether a water modal manager is established per se.
- o An immediate interface issue is emerging in the need to coordinate policy planning of the Corps of Engineers with that of DOT with respect to waterway expansion.
- o The massive proliferation of regulations already alluded to is such that shippers, carriers, and passengers often are confronted with a maze of restrictive regulations which promote inefficiency and stifle innovation, initiative and competition.
- o The Hazardous Materials Transportation Act of 1975 gives DOT

jurisdiction over containers from manufacture to the actual handling of loaded containers in transit.

- o User charges are becoming an issue in the water transportation mode. In the past, waterway facilities were provided on a subsidy basis, free of charge to users. This meant that the average taxpayer funded the facilities rather than the beneficiary of the facilities. Former Secretary Coleman led a school of thought that says fairness and equity demand that users pay for services they benefit from. A major effort will need to be devoted to developing the necessary administrative machinery. The President's 1977 budget called for recovery of \$80 million from inland waterway users.
- o Related to the trend toward imposition of costs on users of government financed facilities and services is a trend toward "value capture." A major new government financed facility in an area usually brings byproduct benefits to businesses in the area. Under the concept of value capture, some of the costs of the facility would be reimbursed by beneficiaries of these byproduct benefits.
- o Management of the Loran C long range navigation system has been a function of the Coast Guard. Use of Loran C is becoming more and more used by commercial ships. A Loran C project office exists in DOT under the Assistant Secretary for System Development and Technology. The function of this office is to manage the implementation of a long range multimodal program for Loran, extending it to other than water transportation.

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